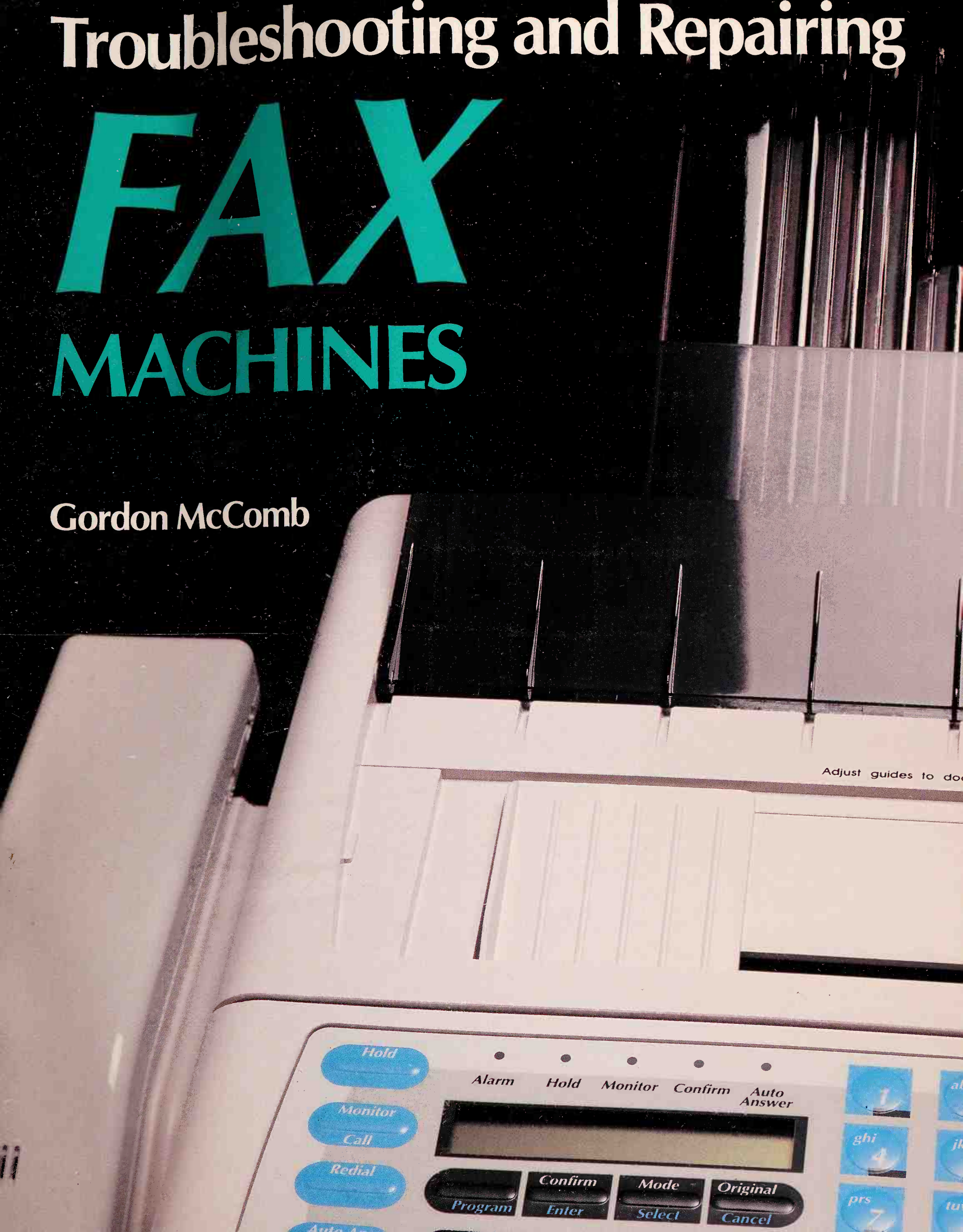
Troubleshooting and Repairing

FAX MACHINES

Gordon McComb



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To Jeffrey McComb,
a big brother in the best ways.

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About the author

Gordon McComb has written more than two dozen books and over 1,000 magazine articles. His writing has appeared in *Popular Science*, *Video*, *Omni*, *High Technology*, *Radio-Electronics*, *Popular Electronics*, *Macworld*, *PC World*, *PC Magazine*, *Computer Buyer's Guide and Handbook*, *Family Handyman*, and dozens of other top consumer and trade publications. His books span a wide range of subjects, from computers to video to robots.

Acknowledgments

I thought this would be an easy book to write.

I was wrong.

Little maintenance information exists on repairing facsimile machines, requiring me to dig deep into the recesses of dozens of faxes, gut them, and find out how they worked—and how they failed. During all this, Roland Phelps, my editor at TAB Books, patiently waited for the manuscript. Though I missed several deadlines, Roland was always willing to work with me to deliver a good book. I hope I didn't let him down.

I also thank Bill Gladstone, literary agent and friend; Jennifer Meredith, wife and friend; and Michael McDowell, writer and friend. All have made some difficult times less stressful.

Introduction

"I can send you the contracts right now if you have a fax machine."

In this age when even overnight delivery is too slow, facsimile transmission allows instant communications to anywhere in the world. Armed with a fax machine, you can beam copies of documents, photos, drawings—any two-dimensional image—across town, across state, or across the country. You can even transmit to other countries and continents—regardless of time zones, languages, or delivery schedules. Fax is the next best thing to being there yourself.

At the heart of this amazing science of facsimile communications is the fax machine, a contraption barely larger than a toaster oven, which somehow gobbles up pages you send to others, and spits out pages others send to you. The fax machine is sort of a combination copier, telephone, and printer. It scans your documents and transmits them over the phone to a remote fax machine. It can also link with distant faxes to print incoming documents.

What's more, it can do everything in a matter of seconds. Most fax transmissions require less than 20 seconds per page. You can transmit the entire German World War II surrender document in about a minute.

Faxes are machines, after all, and therein lies the problem. Machines need care, because they break down every now and then. The cost of sending a fax to an electronics doctor is astronomical—as high as $100 for a simple adjustment. Cleaning and lubricating as fax, which should be done every 12 to 18 months, costs upwards of $100. Owning a fax machine can be an expensive proposition.

Though a fax is a bundle of high-tech circuitry, servo motors and precision parts are not. So, keeping a fax machine in good health needn't be a complicated matter. In fact, taking care of a fax is no more difficult than taking care of your car. Maintaining and repairing a fax machine requires only a small assortment of inexpensive tools and the proper instructions. The tools can be purchased at most any hardware or electronics store; the proper instructions are in this book: *Troubleshooting and Repairing Fax Machines*.

Troubleshooting and Repairing Fax Machines is designed expressly for the consumer. It offers step-by-step details on the care and feeding of home and office faxes—from simple cleaning and lubricating of parts to troubleshooting power supply and logic circuitry problems. It is the first book to cover, in an in-depth but nontechnical manner, the care and repair of all types of fax machines.

Although this book is technical in nature, it does not assume an intimate knowledge of fax communications, telephony, computer technology, electronics, or maintenance and repair techniques. You'll find plenty of introductory information, plus tips that will help you to not only enjoy your fax investment, but save you time and money when (or if) repair time comes around.

About 85 percent of all fax malfunctions are mechanical, so *Troubleshooting and Repairing Fax Machines* spends a lot of time discussing mechanical breakdown—how to avoid it and how to repair it. That doesn't mean the book lacks information on troubleshooting (and in some cases repairing) fax circuitry. On the contrary, every major electronic subsystem of faxes is fully covered, including power supplies, solenoid controls, motors, and more.

Fax machines are loaded with specialty parts, like polished video heads, complex paper-transport mechanisms, and proprietary surface-mount integrated circuits. You can't get these things at the local Radio Shack and most manufacturers don't sell replacement parts to consumers. Even if you could obtain the components, they require special alignment tools and test jigs to test and install them properly.

In the event a fax has a truly serious problem, the home-based technician can do little to effect repairs. Unless you have specific knowledge of servicing your particular brand of machine, an oscilloscope to diagnose waveforms, all the specialty tools on hand, and a service manual, it is better to have serious ailments serviced at a repair center. You are free to attempt large-scale repairs, of course, but they are beyond the scope of this book.

Fortunately, malfunctions in the critical components of faxes are rather rare, even with the inexpensive models. Most problems are caused by such things as dirty switch contacts, broken wires, dirty printing elements, old rubber belts and rollers, and damaged paper. In fact, these represent the greatest percentage of service calls to repair centers. You can fix these faults yourself with a minimum of tools and time.

You can greatly minimize repairs—whether done by you or someone else—by keeping your fax in top shape. This book also presents an easy-to-follow preventative maintenance schedule that you can use to keep your machine working at its fullest.

Even if you can't repair the machine yourself, this book serves another important purpose: it will help you to be well informed about the possible causes of fax problems. You will be better able to articulate your machine's illness to the repair technician. By specifically stating what is wrong, the problem will probably be fixed correctly the first time at a lower cost.

You will also be in a better position to spot unscrupulous repair tactics, like charging for parts that were never replaced, or labor above what was required to service a component. Most service centers and repair technicians are honest and fair, but exceptions do exist. Look out for them!

Time to get to work. Grab your screwdriver, roll up your shirt sleeve, and turn the page. Your journey into the world of fax machine maintenance and repair is about to begin.

1

Introduction to the facsimile machine

Not long ago in this country's history, the mail took two or three weeks to travel from one coast to the other. And that's when the mail got there at all. Stagecoaches were robbed, locomotives were caught in the middle of prairie fires, and unsavory types looted the mail for important documents, like trust deeds, stocks, and bonds. It's hard to imagine conducting business this way, but people did.

Today, the mail system has greatly matured. Correspondence almost always reaches its mark in a timely manner. No more waiting two fortnights to know if you got that new contract; you are alerted in a matter of days. And if you need it faster than that, try one of the overnight delivery services.

But what if you need something delivered in less than a day? What if you need to send some corrected schematics, plans, budgets, or whatever to the big meeting which is going on right now? The answer: facsimile.

The facsimile machine (or fax) has become the mainstay of the modern American office. Fax machines are even found in many homes. The fax machine has become *the* communications tool of the 1990s, allowing instant communication of documents to anywhere in the world. The telephone allows us to speak to others in distant parts of the globe; the fax machine does one better and allows us to transport entire documents at the touch of a button.

This chapter reviews the basics of the fax machine: what it is, standards, differences in machines, and the fundamental operation. In chapter 2, which digs into the nitty-gritty of facsimile design and engineering, you'll learn more about what a fax machine is and how it works.

A short history of fax

Thomas Edison was sure that his new electromechanical device, the phonograph, would charm the populace with recordings of great singers and statesmen on foil cylinders. Alas, it took more than 10 years to catch on, and by then, a competing system

began to steal the show. Alexander Graham Bell was stymied when his innovation, the telephone, literally took decades to become a financial success.

Alexander Bain fared no better than these famous inventors. Bain was first to propose, in 1842, the idea of transmitting pictures through wire from one point to another. This technique, now 150 years old, marks the birth of facsimile. Bain's crude prototype facsimile machine consisted of a pendulum that was fitted with a stylus. The needle-sharp stylus carved an image on a piece of shellacked metal. Facsimile-by-wire transmission didn't become a reality until 1854, and by 1863, the Pentelegraph Corporation of Paris announced the first public facsimile service.

Facsimile then languished for almost a century. Its use was largely limited to newspapers and police departments for broadcasting pictures across country. The fax machines of the age were slow and cumbersome. To receive an image, the sender had to use the same type of machine as yours, which greatly restricted the number and variety of people you could communicate with.

In the 1970s, limited interest of fax for general business use was rekindled when a modest standard of facsimile transmission was devised. This standard allowed two machines of different manufacture to send and receive a single letter-size page in approximately six minutes over the telephone lines. A few years later, a slightly improved version was released that transmitted a single document page in three minutes.

It wasn't until the 1980s, specifically the latter part of the decade, that facsimile caught on like brushfire. Why the sudden reawakening of fax? The answer is simple: digital transmission. One of these modern fax machines is depicted in FIG. 1-1.

Fig. 1-1. A modern facsimile machine.

Early fax machines, even those built as recently as 10 years ago, were hamstrung by antiquated analog transmission (see FIG. 1-2). The image on the page was converted to a series of complex tones; these tones in turn were relayed from one machine to another through the phone lines. Not only were the tones subject to noise (which smeared the image), but the sequencing of tones greatly slowed the transmission.

Conversely, the latest fax machines use digital transmission to send and receive a page in one minute or less. Digital transmission (FIG. 1-3) also uses audible tones, but these tones are fewer in number, and represent digital information (1s and 0s) known as *bits*. Digital bits can be readily *compressed* so that one line of a page can be transmitted in just a fraction of the time that was required with the old analog method. In addition, computer circuitry on both ends of the fax link ensure that the information sent and received is accurate. If bits are missing, or were garbled by line noise, they can be easily retransmitted so that you are ensured of a near-perfect copy at the destination.

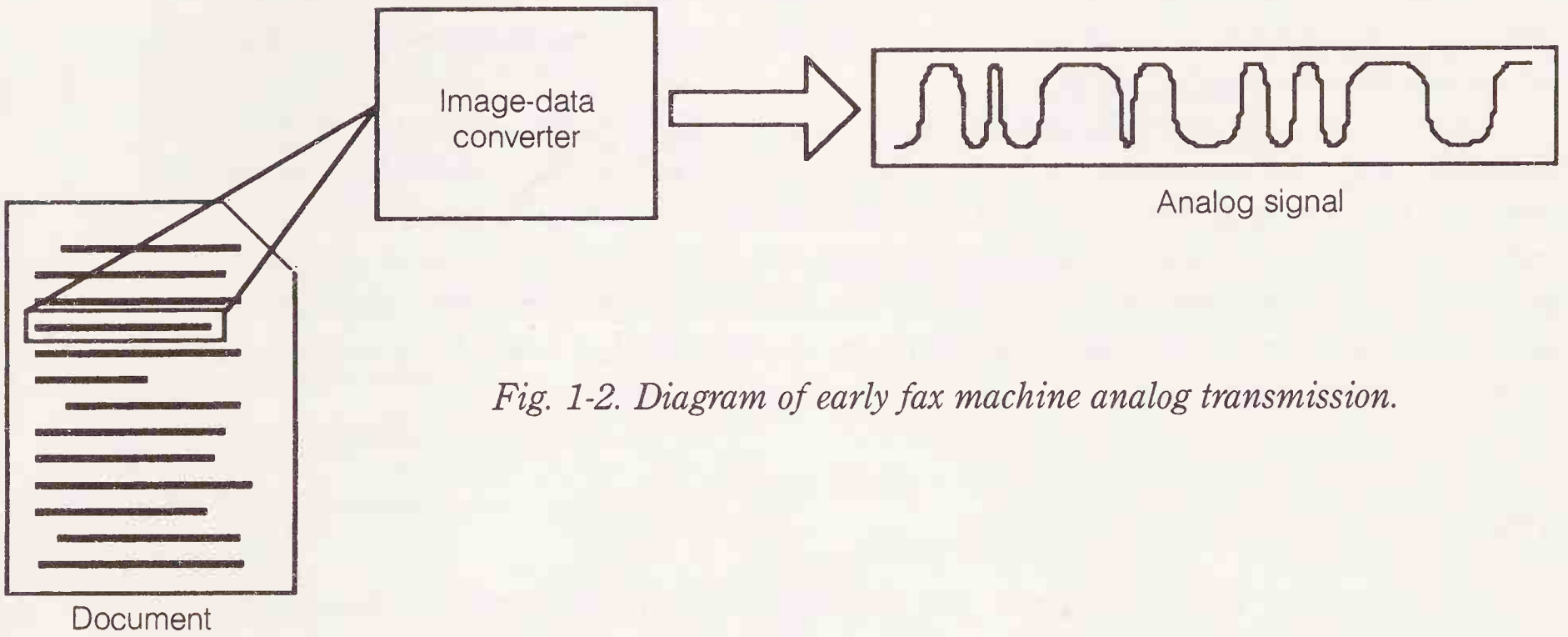


Fig. 1-2. Diagram of early fax machine analog transmission.

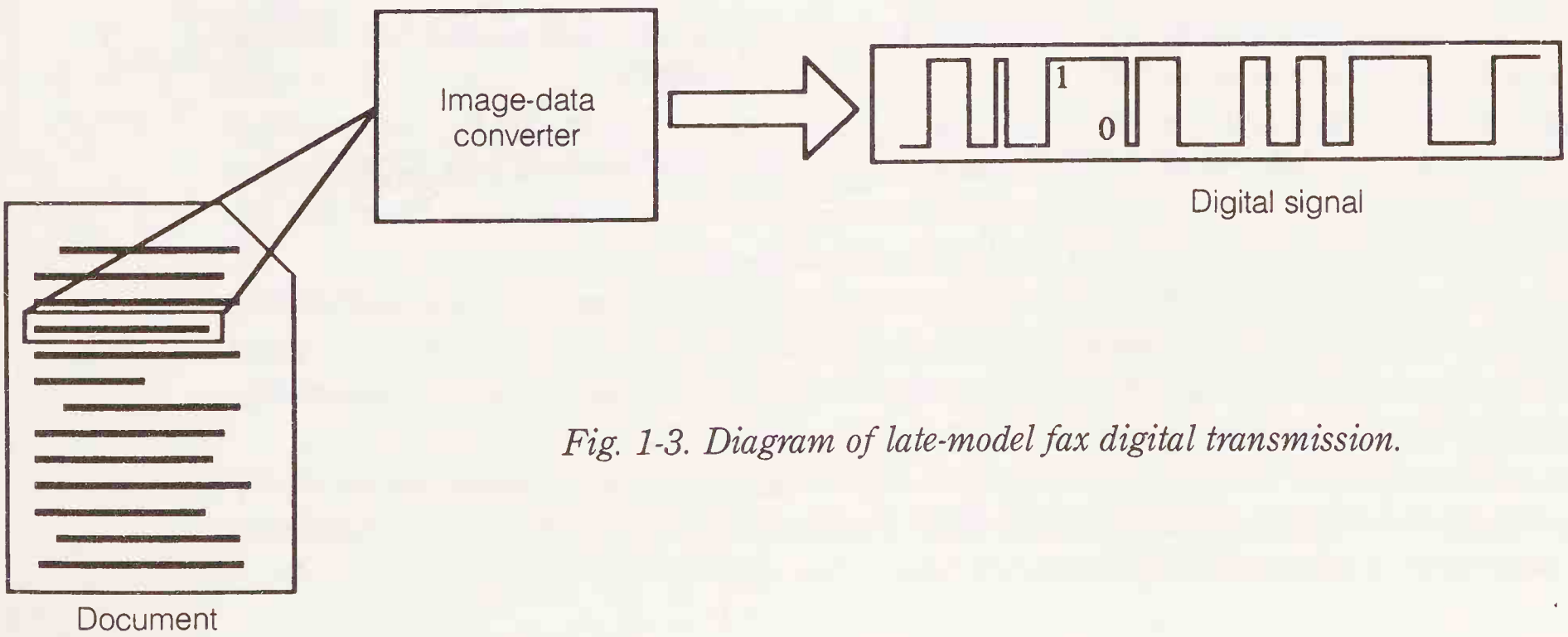


Fig. 1-3. Diagram of late-model fax digital transmission.

Why fax?

Facsimile offers a cost-effective alternative to overnight and messenger services. Even if you have lots of pages to send to someone, you might still save money if you use the fax machine (whether or not the call is long distance). For example, it costs approximately $2.50 for a five-minute phone call from Los Angeles to New York. In that five minute period, 5 to 10 pages can be transmitted via fax. If you are sending a long letter or a 5- to 10-page report, the total cost is $2.50.

Most all fax machines let you save even more money with unattended dialing (we'll cover this and other features later in this chapter). The machine is loaded with the documents to send and a list of phone numbers to call. The fax machine then calls each number and sends the proper documents to the fax machine on the other end. With unattended calling, you can take advantage of the lower rates in the evening or even on weekends.

Obviously, some types of documents can't be faxed: checks, original contracts, etc. But the vast majority of business correspondence is in the form of letters or reports, which are easy to transfer via fax.

Besides cost, the facsimile machine is convenient. Depending on the document, it might be easier for you to send it by fax than to address an envelope and drop it in the mailbox. If you're ordering from a catalog, you can place your order by fax, rather than call it in. Because the ordering department has a written description of what you want, errors aren't as likely. And if you became a "fax fanatic," you might go one step further and order pizzas and other food via fax (many restaurants are adding fax machines; they take orders faster and don't require human intervention).

Fax standards

If you are familiar with computers, you know that very little standardization exists among competing brands. You can't run Macintosh software on an IBM PC, for example (at least, not without a sophisticated conversion, which degrades system performance).

Fortunately, facsimile transmission is standardized. Various makes and models share a common communication protocol, identified as Group 1, 2, 3, or 4. These standards were established by the nonpartisan Consultative Committee for International Telephone and Telegraph (CCITT), based in Geneva Switzerland. The CCITT standards are worldwide, which means that you should be able to use your American fax machine to call Germany, Japan, Australia, England, etc.

However, other countries have different telephone equipment standards than the United States, so calls to foreign countries might contain more data errors. That means some facsimile calls might not be successful or might take longer as a result of retransmission caused by frequent errors.

The old-style fax machines, Group 1, were the slowest of all, requiring about six minutes to transmit a single page. Group 2 machines were a little faster, with transmission times of about three minutes.

Both Group 1 and Group 2 faxes use analog technology to send images from one location to another; they are still employed by some news agencies and police departments. Functional diagrams of the send and receive portions of analog facsimile are shown in FIGS. 1-4 and 1-5. This book doesn't feature these early Group 1 and Group 2 fax machines. However, it is interesting to know a little bit about how they work, and how they differ from the current crop of all-digital Group 3 machines.

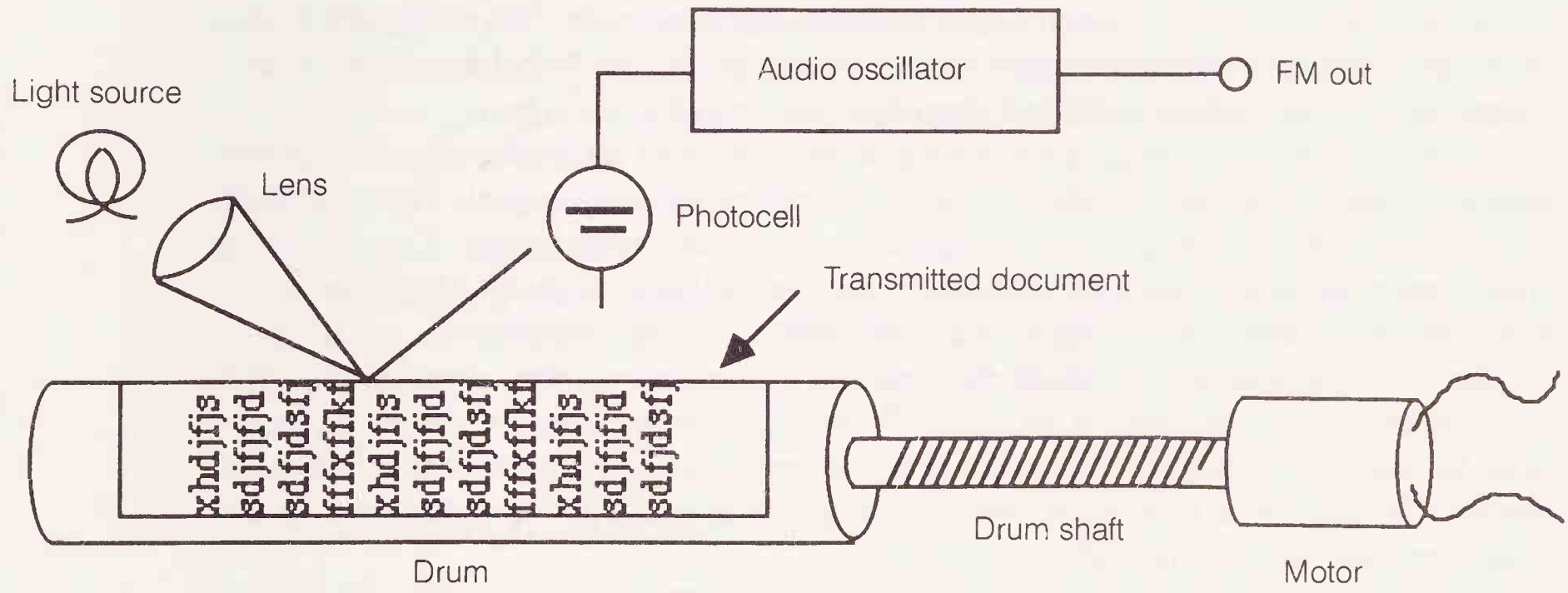


Fig. 1-4. How analog fax machines "dissect" the page for transmission.

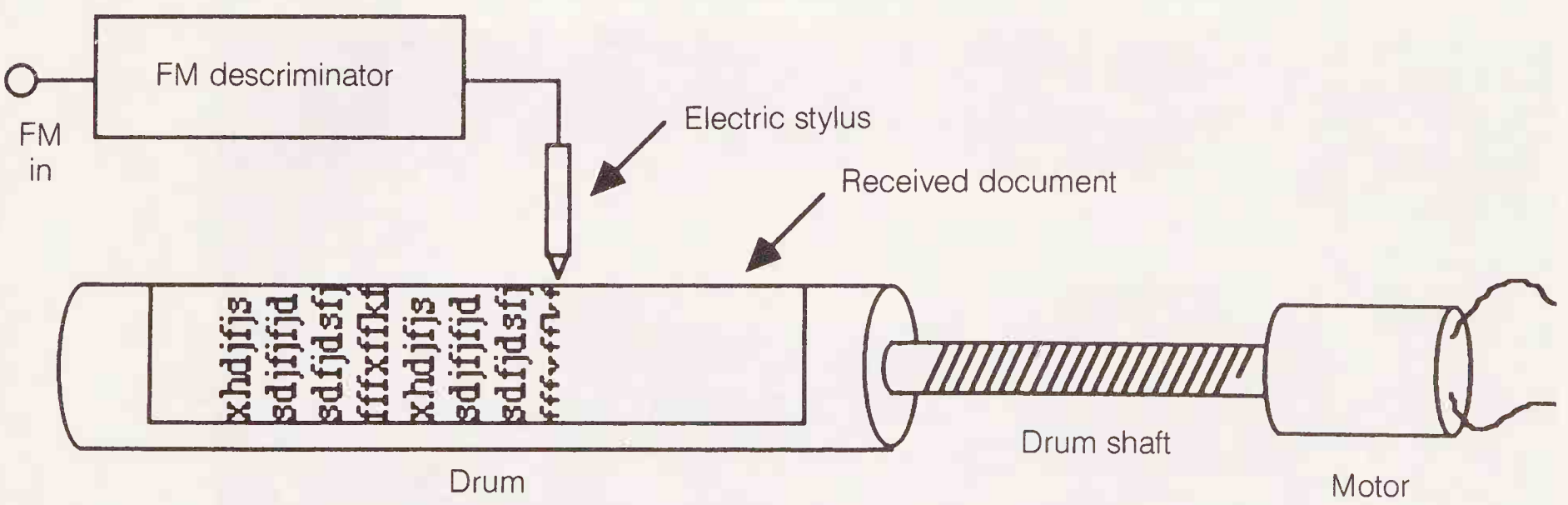


Fig. 1-5. How analog fax receive and print documents.

In a Group 1 or 2 machine, the document is attached to a large drum. This obviously restricts the size of the document to standard dimensions, such as letter or legal size. You can't wrap a larger document onto the drum because it won't fit, and a smaller document will either fly off or become crumpled when the fax machine is turned on.

To send a document, a light beam is reflected off the page and directed into a photocell. As the drum rotates, the photocell picks up the variations in the light and dark, which denote printed areas of the paper. With each subsequent rotation of the drum, the photocell moves down a bit so it can scan the entire length of the page.

The photocell is connected to an audio oscillator that converts the variations in light and dark from the page to audible tones. The resulting "symphony" of tones is then sent through the phone lines and is received by the remote facsimile machine.

To receive a page, the remote fax is outfitted with a sheet of heat-sensitive or electrically-sensitive paper (different fax models used different approaches for printing received documents). This sheet is also wrapped around the drum, and the drum is synchronously rotated with the sending fax. As the drum rotates, electricity or heat is applied to a needle-sharp stylus in response to the received tones. The stylus either produces heat for heat-sensitive paper or an electrical charge for electrostatic paper. Where heat or electricity is applied, the paper becomes black.

The limitations of Group 1 and Group 2 fax machines are rather clear. First and foremost: any glitch in the phone line disrupts the received signal. A momentary "click" on the line might produce a long black line in the printed page. This limitation often forces these fax machine owners to use specially-conditioned telephone lines, which must be leased at an appreciable cost from the phone company.

Second, the operators of both the sending and receiving fax must monitor the progress of the transmission at all times. When sending multipage documents, paper must be manually changed. Although reception won't start before the transmitting fax machine is ready, and vice versa, you can imagine the problems in synchronizing the efforts on both ends of the link.

All the latest fax machines follow the Group 3 standard, which eliminates analog transmission and replaces it with far more efficient digital transmission (see FIG. 1-6).

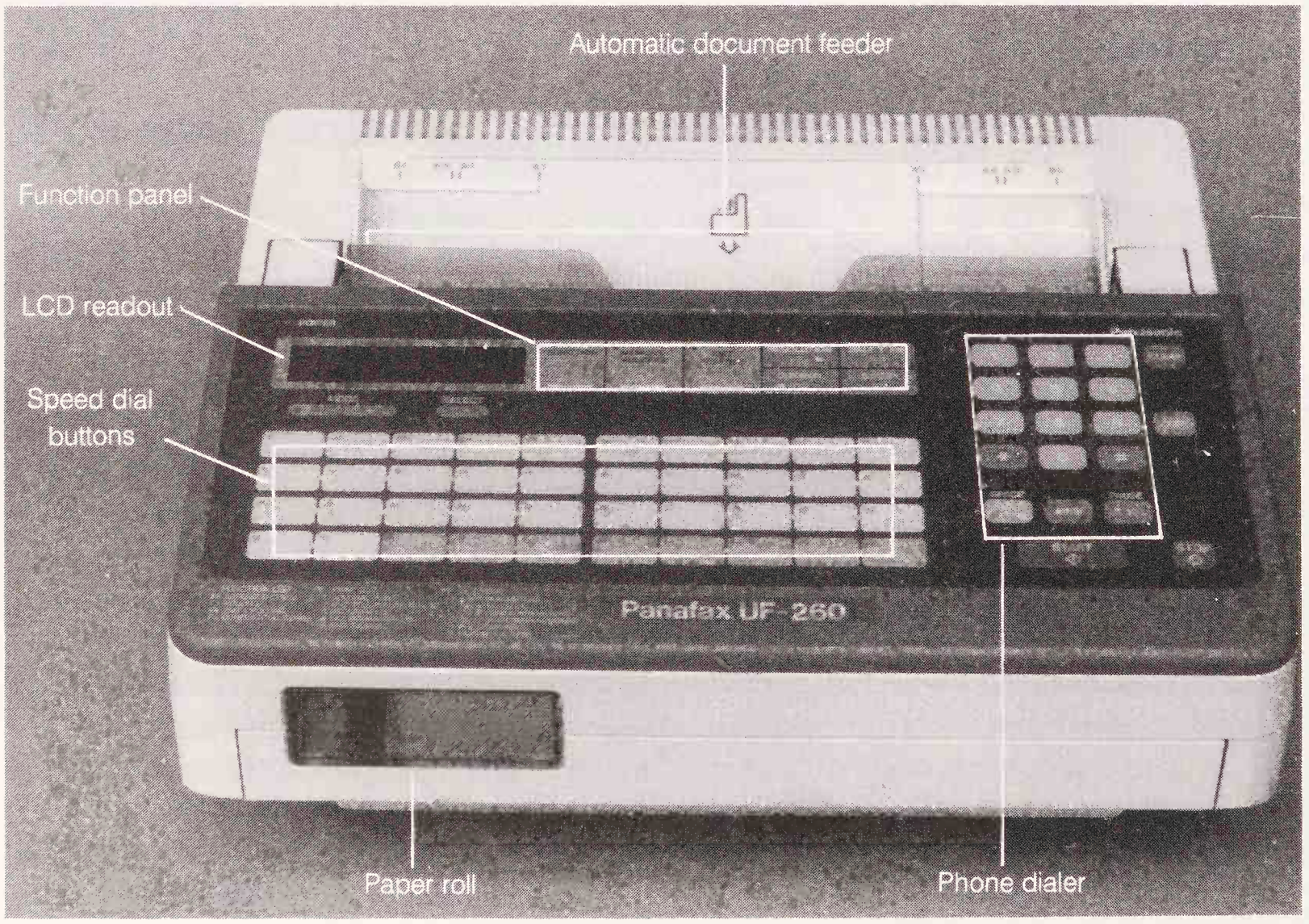


Fig. 1-6. Components of a digital fax machine.

Digital faxes use a light beam to "read" the page and thermal printing technology to print the received page. Today's faxes don't use rotating drums, so they can accept various sizes of paper. Most faxes accept a small stack of paper (usually under 30 sheets) and automatically feed them one at a time through the machine. This addition is very convenient when sending multipage documents.

The transmission time for a Group 3 fax is one minute or less, depending on the page being sent through the wire. Many documents can be transmitted in 15 to 20 seconds, not including the time to initiate the call.

A Group 4 standard has already been established, but although it's ready to go, the nation's phone lines aren't. Group 4 facsimile requires a high-speed, all-digital phone system to operate properly. This phone system, called *ISDN* (*Integrated Services Digital Network*), won't be common in this country until far into the 1990s, and possibly not until the turn of the century.

Group 4 fax machines do exist and they are used primarily for very fast document transmission, but they are limited to businesses who have leased special lines from the phone company or who use alternate high-speed transmission channels.

How modern fax works

A facsimile machine is both a scanning device and a printing device. In the send mode, the fax machine passes an optical assembly over the page and transforms the light and dark areas into digital signals. These signals are then converted to tones, much like a computer modem. The tones allow long distance communications with another fax.

In the receive mode, the fax machine captures the tones, converts them back into digital information, and prints the result on a sheet of special thermal paper. The thermal printing technique is similar to one used in thermal computer printers. Points on a printhead become hot and turn the paper black (or dark gray). The points of heat produce the dots that compose the image of the document.

The system of transferring the image of a page by dots has its limitations. The page must be reduced to a series of digital bits and reproduced as a collection of tiny dots. The resolution of the sending and receiving machines (particularly the receiving machine) determines the quality of the output. With fax machines, resolution is usually stated in lines per inch or dots per inch. The higher the resolution, the finer the detail.

The average resolution of a Group 3 fax machine is about 200 by 200 dots or lines per inch. That's far better than most dot matrix computer printers, but not quite typewriter quality. Many fax machines have multiple resolution. For example, in *fast* or *standard mode* (different machines go by different terms), the resolution is 98 by 204 lines per inch (204 lines per inch horizontally and 98 lines per inch vertically). Documents are transmitted and received at about 18 seconds per page. In *fine* or *detail mode*, the resolution is increased to 196 by 204 lines per inch (same horizontal resolution, but 196 lines per inch vertically). The transmission speed is increased by about 40 percent, to 25 seconds per page.

The latest trend is *plain-paper faxes*. The end-end machines use laser printing technology, just like computer laser printers. The collection of dots that compose the image are scanned onto a photosensitive drum with a laser. The image on the drum is then

imparted to a piece of plain paper with dry black toner. Laser faxes have an inherent higher resolution than thermal faxes (300 to 400 dots or lines per inch), and they operate faster. The disadvantage is that they are expensive. The average cost of a thermal fax is less than $1,200. The cost of a laser fax is between $5,000 and $7,500.

A cheaper way to produce plain-paper faxes is to use thermal-transfer technology. These are almost identical to a standard fax—a heat-producing print element is still used to create the image on the page. The difference is that thermal-transfer fax machines use a heat-sensitive ribbon to print on unsensitized paper. Where the ribbon is heated, the ink melts and is deposited on the paper. Actually, "plain-paper" is a misnomer when applied to thermal-transfer fax machines. For best results, a special coated paper should be used with thermal-transfer faxes. The melted ink adheres better to the surface of the paper.

So far, the mechanics of fax machines have only been briefly outlined. Chapter 2 provides a more thorough look, including a thorough discussion on fax specifications, an inside look at printing technologies, and more.

What is a fax document?

A fax document is a collection of dots that are transmitted one speck at a time through the phone lines. Like any picture, even though a fax document might contain text, each character is merely a collection of dots on the page.

You can prepare a document for fax modem transmission with a typewriter, ink, crayon (though not recommended), computer printer, or most any other means. You can even make a pencil sketch for fax transmission, though the results on the other end won't be very good (chapter 3 deals more with achieving optimum quality).

Fax documents don't have to be actual pieces of paper. If you have a personal computer, you can add a "fax modem" board, which electronically sends fax documents without first scanning a sheet of paper. Data (text, graphics, or both) is first converted to a digital fax format, then transmitted to the receiving fax. That fax can be a stand-alone machine or another computer that is equipped with a fax modem.

Computer fax has become increasingly popular over the years, especially because the price is less than 25 percent of a full stand-alone fax machine. Although computer fax modems don't require the same mechanical maintenance and repair as regular fax machines, electrical problems can occur. These problems are featured in chapter 10.

Basic operation

All facsimile machines have the following specifications and features:

Page size and print width

All fax machines accept paper up to 8 1/2 by 11 inches. The scanning width might be smaller than this, however. It's not unusual for a fax to chop off 1/2 inch on either side of the paper as a result of the internal design of the machine. The printing width might be

even smaller. In almost all faxes sold today, if the received page is larger than the printing width, the machine will automatically reduce the image so that all of it fits on the page. That way you don't lose the edges.

Dialing

Only the lowest priced fax machines have no internal dialing capabilities. With these, you dial manually with a telephone (or an autodialer) connected to the fax. With the majority of Group 3 fax machines, the dialer is built in.

Auto answer/reception

Faxes are meant to be attached to their own dedicated line (however, most let you share it with a voice line, which can be automatically and manually switched back and forth). Because they have their own line, they can be connnected to it 24 hours a day, 365 days a year. Calls can be received at any time because you don't need to be there to answer it. The fax answers the call after the first or second ring, identifies itself, then readies itself to receive a page.

Whether or not you are there when the call comes in, the fax will receive the page and print it out. As long as it has enough paper for the entire transmission, and no jam or other physical problem hinders operation, the fax machine will receive the entire document automatically.

Remote identification

When you call someone on the phone, you use human intelligence to detect when you are talking to the right person. Even if you don't know the person, and have never spoken with him or her before, you can exchange greetings and be fairly assured that you are talking to the right individual.

Calls to fax machines are a little different. Even to another fax, all machines sound the same. Fax machines have an identification system that helps avoid sending material to the wrong person. When you call someone, for example, the receiving fax identifies itself when the phone is first answered. That identification is often flashed on a screen or LCD panel (if the machine is so equipped). If you have called the wrong fax, you can hang up and try again.

Copier function

If you don't have a copier in your home or office, you can use most any fax to make routine copies. Place the original in the automatic document feeder and press a *copy* or *self-test* button. The fax then makes a copy of the original onto its thermal paper.

The built-in copier function also helps when sending documents to others. Suppose you want to send a four-page newsletter by fax. The newsletter is printed on a single 11-by-17-inch page, folded in half. If you tried to send the newsletter as is, you'd be busy folding the paper to the proper page and inserting it into the machine. If your fax can send a stack of pages at a time, it will likely terminate the call after sending just one page, because it will think you are all through.

A better way: prior to faxing the newsletter, use the copier function to make copies of each page. Place the copies in order, then send those. The quality of the transmission is reduced somewhat, especially if the newsletter contains photographs. If you need to retain as much quality as possible, copy the original on a plain-paper copier first. You will learn more about achieving maximum results in chapter 3.

Group 3 standard and transmission speed

All fax machines sold today adhere to the Group 3 standard. This standard governs the way data is transmitted and received. The standard transmission speeds are 2,400, 4,800, 7,200, and 9,600 data bits per second (or bps). Fax manufacturers can shave a few dollars off the price of the machine by using a slower transmission speed.

You are ensured of the fastest possible Group 3 transmission when the machine sends and receives data at 9,600 bps. Transmission time is doubled if the machine operates at half the speed, 4,800 bps. All fax units are able to "fall-back" to a slower speed if they encounter another machine that can't keep pace. For example, even though your fax machine has a top speed of 4,800 bps, you can still communicate with a machine that is capable of sending and receiving at 9,600. The remote machine will recognize that yours can't communicate at the fast rate and it will automatically shift into lower gear.

The enhanced fax machine

Plenty of special features are available on the more advanced fax machines. Here's a rundown of the enhancements you'll see on machines in just about every price range:

Speed dial and redial

If you call the same people time and time again, program their phone numbers into the fax machine's dialing memory. When you want to send a fax, you only need to press one button, instead of one half dozen or more. This process is called *speed dial*, and it is included on most mid- to high-end facsimile models.

In addition to making your life a little more convenient, speed dialing also helps reduce the number of wrong numbers. Wrong numbers and fax machines don't mix, because the phone might be answered by a human. It might take your fax machine up to a minute to realize that another machine isn't on the other end. If you're dialing long distance, that could be money down the drain (most long distance carriers will refund you in the case of a wrong number, but it's far more cost-effective to get the number right the first time).

A last-number redial feature lets you automatically recall the last number in case you get a busy signal. You can use last-number redial whether or not your fax has speed dialing.

Activity reports

As a bookkeeping feature, many fax machines provide a written report of the calls it has made, as well as the calls it has received, called *activity reports*. You can use the

report to track expenditures or you can use it to verify that the documents you sent actually got to their destination. This feature is particularly important if you are using your fax in the unattended mode. The report is generated either automatically after so many transactions or is kept in a memory inside the fax and printed out, as desired.

LCD readouts

An *LCD* (*liquid crystal display*) readout is like a miniature TV screen; it is used to relay important information to you. For example, the readout might show you the number it is dialing, an error message as a result of a faulty phone condition, or some other bit of information. Low-cost fax machines often do without the LCD readout, and instead rely on a small handful of activity lights.

Send/receive bin capacity

The basic fax machine can send just one page at a time. You have to manually load each page during transmission. The majority of fax machines, however, can accept anywhere between 5 and 50 pages in an automatic document feeder. The *automatic document feeder* (*ADF*) is similar to that which is found in a plain-paper copier. It takes one page from the bin at a time and processes it through the fax. Office fax machines are generally designed to handle about 25 to 30 sheets, which should be enough in most instances.

Similarly, the receiving bin is where the received documents are placed after being printed by the fax. If your fax has such a bin, it might hold 25 to 75 sheets, more than enough for even the busiest day. However, a number of fax machines lack a receiving bin; rather, received pages are just dropped into a basket that is placed under the unit.

Personal, portable, or stand-alone

With the exception of the laser units, most fax machines are stand-alone models. They fill about the same space as an office typewriter or a small copier. The "footprint" of the fax can be enlarged, however, by the addition of paper bins and automatic document feeders.

Stand-alone fax machines are meant to be plugged in and left in the same spot—ideal for large businesses and corporations. A portable fax can be taken with you, and stashed in a special carrying case or even in your briefcase. Many portable models weigh less than eight pounds and run on ac or dc power. It can be acoustically connected to any standard or mobile telephone (even a cellular car phone) and send or receive for up to 15 to 30 minutes on a single battery charge.

A third genre of the fax is the "personal" model, so called because it offers fewer features than the more costly stand-alone units. Personal fax machines might lack one or more of the exotic bells and whistles found on a stand-alone model, but they are nevertheless ideal for use in the home, where these features are not often missed.

Automatic paper cutter

Whether stand-alone, portable, or personal, most fax machines use a continuous roll of thermal paper for printing received documents. As pages are received, an automatic paper

cutter trims the pages to the proper length. Without the cutter, the documents come out as one long sheet. Then, you can trim the pages to length using a pair of scissors.

Automatic paper cutters are found on stand-alone models, but are lacking on many portable or personal units, because of size and cost.

Multifunction

Fax machines that are designed for the small business office often combine a number of telephone features into one unit. In addition to the facsimile hardware, the machine might also include a phone handset (for talking over the phone line), a phone answering machine, a speakerphone, and more.

Page memory

One of the disadvantages to unattended fax operation is that if the paper runs out, subsequently received documents will be lost. That problem can be avoided by using a fax with built-in memory. Such fax machines are equipped with *random-access memory* (*RAM*) for holding anywhere between 60 to 600 pages (memory capacity one to 10 megabytes).

Reduction and enlargement

It is sometimes necessary to squeeze an extra wide document onto small paper. Most fax machines have this feature, but fewer have an enlarge capacity. Image enlargement can be used to increase the size of a picture or drawing so that fine details can more easily be seen, or to increase a squeezed transmitted document to normal size.

Page feed vs. flatbed

The vast majority of facsimile machines are the page-feed variety. Insert a piece of paper in one end and the machine slowly draws it past an internal optical assembly.

With the flatbed variety, you place the page face down on a glass stage. Close the cover (much like on a plain-paper copier) and the optics move from one end of the glass to the other. Flatbed fax machines are typically used when the size of the document pages are nonstandard or mixed. Most flatbed faxes come with (or have available as an option) an automatic document feeder attachment, so you don't have to manually place each page on the glass stage.

Thermal-transfer printing

A small number of the newest fax machines use an improved thermal-transfer printing technique. Most fax machines heat specially sensitized paper. The hot spots turn dark. With thermal transfer, a waxy ribbon is heated instead, and its ink is transferred from the ribbon to the paper.

The benefit of thermal transfer is that the paper lasts longer in storage and isn't as susceptible to damage from heat and sunlight. The paper used in thermal transfer

faxes is a special-coated stock, which accepts the liquefied ink from the ribbon better than plain paper. Plain paper can be used, but the fax quality isn't always high.

RS-232 computer interface

Those stand-alone fax machines that contain their own memory might also have an RS-232 serial interface to connect it to a computer. Once connected, the computer can transmit text to the fax machine for storage in the unit's memory. The interface allows you to send documents without having to print and feed them through the fax machines. The main benefits of the RS-232 serial interface are speed and convenience. These interfaces are mostly intended for those businesses who send and receive several hundred fax pages per day.

Speed

Not all Group 3 fax machines are speedy little critters. The Group 3 fax standard actually specifies a slower speed than is used in most commercial models available today. The transmission and reception speed of a fax machine is stated in bps. The more bits that can be sent through the phone lines at once, the faster the finished document will appear on the other end.

The fastest Group 3 fax machine operates at 9,600 bits per second. These models can send and receive a one-page document in under 20 seconds. Conversely, the Group 3 standard calls for 2,400, 4,800, and 7,200 bps. Manufacturers can cut a few corners by using one of the slower transmission speeds, which means that your fax might not send and receive documents at the rate of one page every 20 seconds or so.

As mentioned earlier in this chapter, fax machines can "fall back" to a slower transmission speed if the phone line is extra noisy. The slower transmission speeds are not as susceptible to noise on the phone line. Even if your fax operates at the full 9,600 bps speed, a noisy phone line might slow the transmission time to one minute or more per page.

The computer fax

An expansion board can turn an IBM PC or compatible into a fax machine. Several such expansion boards are available at prices that are generally far less than stand-alone facsimile machines. Of course, these computer fax boards don't have all the features of standard fax machines, but they are admirable alternatives, especially if you are on a tight budget.

Fax boards slip into an empty expansion slot in the PC and use the computer's memory and screen to store and display pages. Received documents appear on the screen, then they can be stored onto magnetic disk or transferred to paper with a suitable dot-matrix printer.

Pages can also be transmitted from the computer. The pages can either be screen images that are captured into the computer's memory or text documents that are transferred to fax-equivalent graphic images. The images are transmitted as pages to the receiving fax.

If you have an optical scanner, used (for example) for desktop publishing, you can use it to process the image of the pages into the computer. That way, you don't have to use documents that are prepared by the computer. You can transfer anything that you can fit into the scanner.

Not all computer faxes are expansion boards. Some are self-contained modules that connect to the computer by way of a serial port. These modules can be used with PCs that lack a suitable expansion port or by other computer brands, such as the Apple Macintosh. See chapter 10 for more details on the computer-based fax.

2

How fax works

Understanding the way your fax machine works is an integral part of knowing how to fix it if it breaks. Although routine maintenance procedures and home (or office) repairs do not require a scientific explanation of how the "eye" of a fax reads the light and dark portions on a piece of paper, it is helpful to know the basics of fax operation.

This chapter details the technical inside workings of fax machines, with complete explanations of the paper transport, how the sending page is converted to electrical impulses, how the received page is printed, and more.

Fax machines are "transceivers." That is, they both send and receive, like two machines in one. The first half of the fax machine reads the contents of a page and sends it down the telephone wire. The second half receives the signal and reconstitutes it on another piece of paper. Because of this two-part process, the inner workings of fax machines are covered in two discrete sections.

Sending a document

Document transmission is basically a three-step process. For the time being, assume the document consists of just a single page and that the fax machine is the standard feed-through type.

1. The page is fed into the fax machine by a precise stepper motor. The stepper motor inches the paper through the machine in discrete steps so that its movement can be carefully controlled. During this process, the image on the page is scanned by a light-sensitive pickup device. The pickup device sees the document in varying levels of brightness—typically just black and white—denoting printing on the page.
2. The pickup device is connected to a circuit that converts the varying levels of brightness to digital form, 0s and 1s. The conversion process is complex and it involves not only translating the page to digital form, but also compressing the data so that transmission time can be reduced.

3. The converted/compressed digital data is transmitted through the phone lines via a modem. The modem (*mo*dulator/*dem*odulator) converts electrical impulses into audible tones.

Take a closer look at each step.

Image scan

Paper documents are two-dimensional, with a printed image that extends up-and-down and side-to-side. In order to scan the entire surface of the page, the fax machine must examine the image on a line-by-line basis, starting from the top and working its way down.

Each line spans the width of the page—normally 8 inches. In standard resolution, each line is only 1/100 of an inch deep. Assuming that the page is 11 inches long, the machine must repeatedly scan the image 1,100 times. With each scan, the machine picks up a little more of the image (FIG. 2-1).

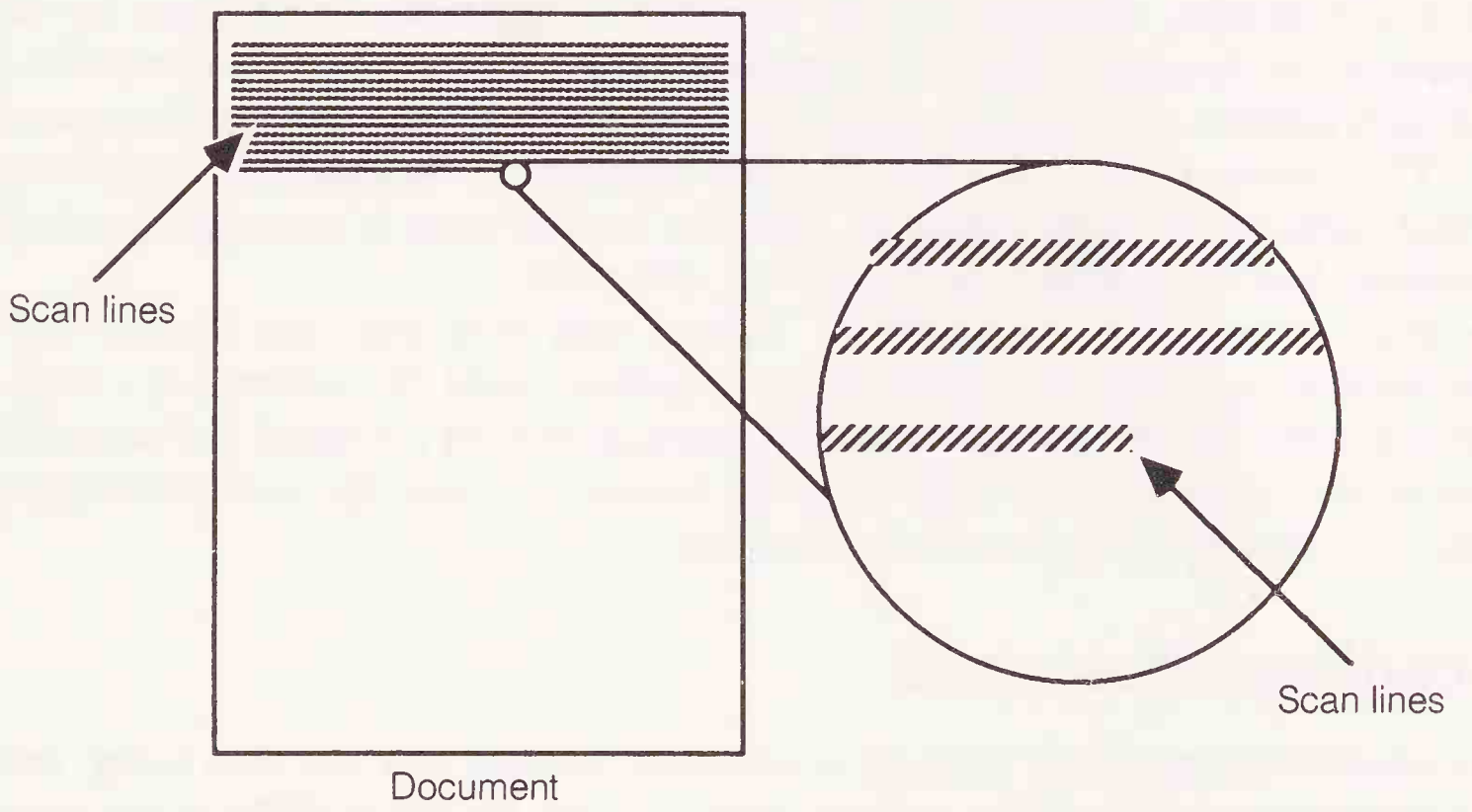


Fig. 2-1. Fax machines scan each page of a document, line by line.

In a feed-through fax, the paper runs through the machine like a car through a car wash. The optical scanner is located inside the fax machine, and it sweeps back and forth as the paper passes through. The sweeping action is usually accomplished with a tiny multifaceted rotating mirror. The light-sensitive "eye," typically a *charged-coupled device* (*CCD*), remains stationary. Figure 2-2 shows how it works. The combination of the optical sweep and the movement of the page through the fax enables the machine to scan the two dimensions of the page.

Other scanning techniques are employed as well. One uses a single light-sensitive sensor that is composed of about 1,700 individual CCD elements. As shown in FIG. 2-3, a lens focuses a strip of light from the paper into the light-sensitive sensor.

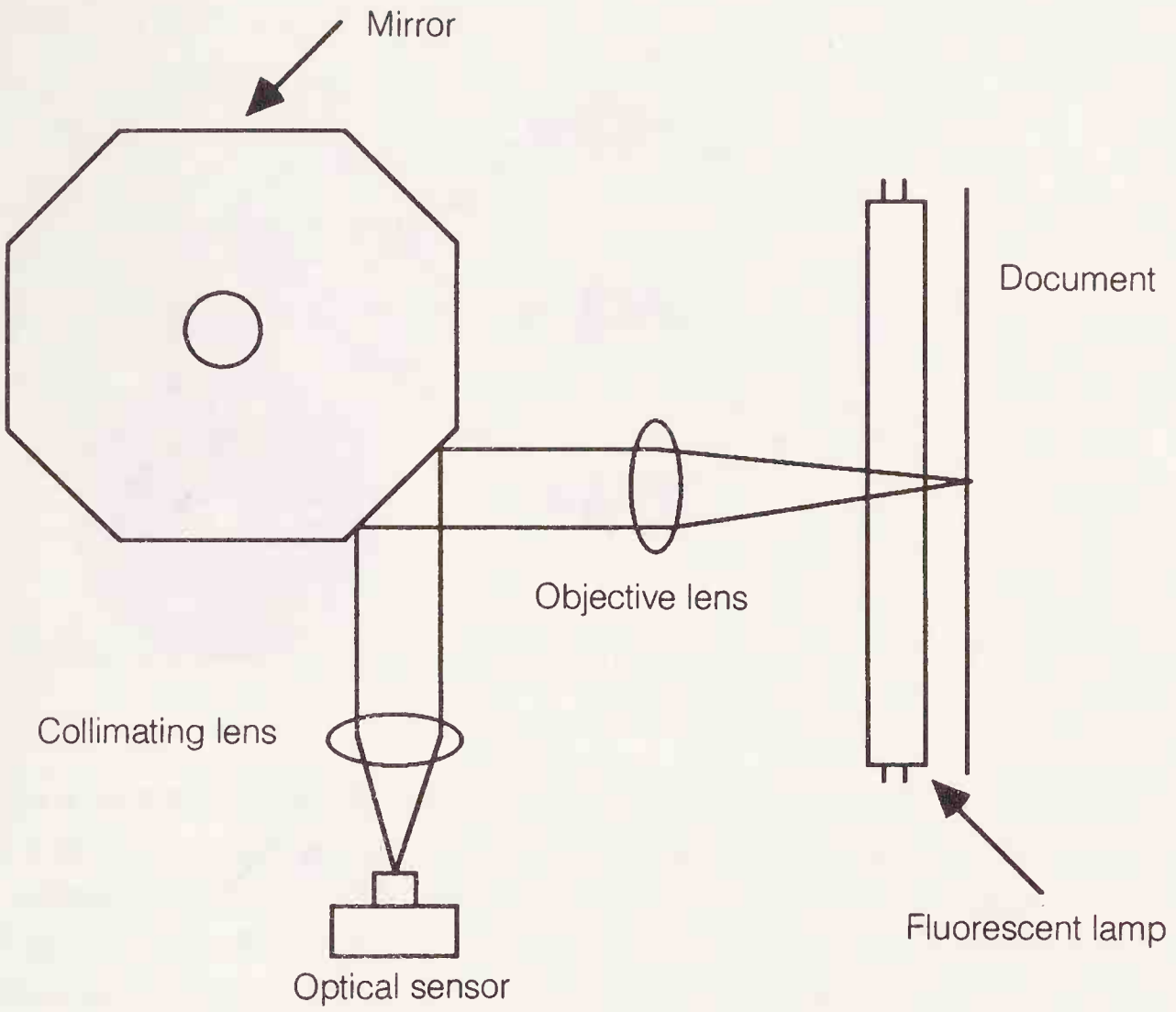


Fig. 2-2. The optical scanning mechanism of the typical fax machine.

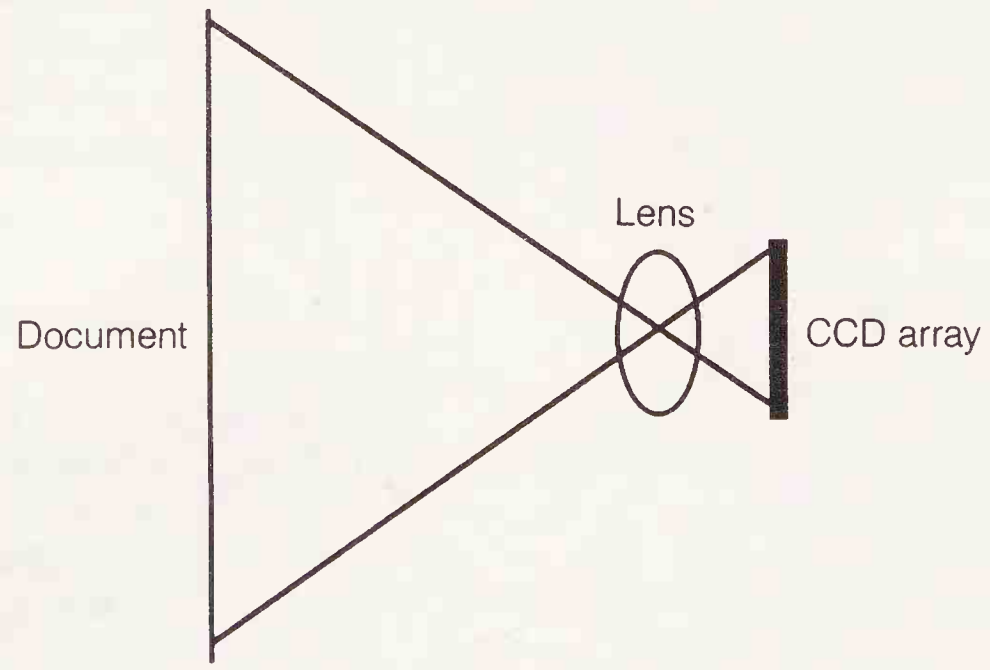


Fig. 2-3. Some fax machines use single-element charge-coupled device (CCD) to scan an entire line at once (the element contains over 1,700 individual "eyes"). No scanning mechanism is used.

In yet another form of fax image scanning, depicted in FIG. 2-4, the machine uses three light-sensitive sensors, each of which contains over 550 individual CCD elements. Three lenses focus light from the page and direct it to the sensor. The advantage of both of these methods is that no spinning mirror is used. This helps reduce image problems that are caused by optical misalignment and vibration.

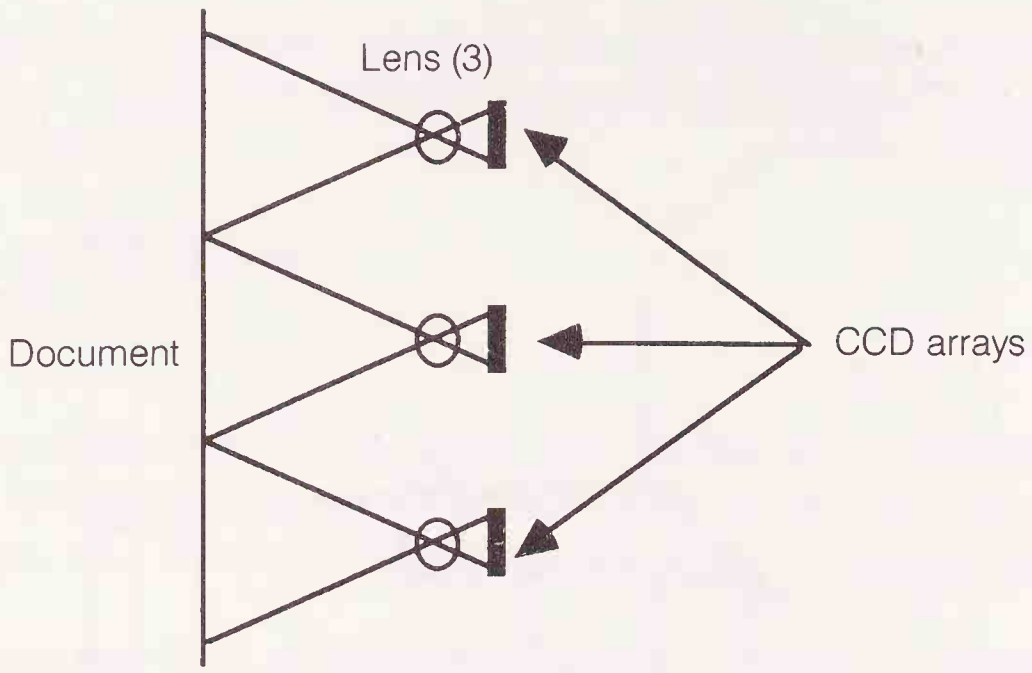


Fig. 2-4. Three CCD elements are each scanning a portion of a line. No scanning mechanism is used.

In a few, higher-end fax machines, the optical assembly consists of a solid row of CCD light-sensitive components. This is the *CCD array*, also referred to as a *reader bar* or *strip*. No rotating mirror is used; rather, the row of CCDs picks up an entire line all at once. The reader bar (FIG. 2-5) contains 1,728 individual CCD elements. The benefit of the CCD reader bar is speed and accuracy. Documents can be scanned faster and with a higher degree of precision than with a single CCD and a scanning mirror. The major drawback is higher cost.

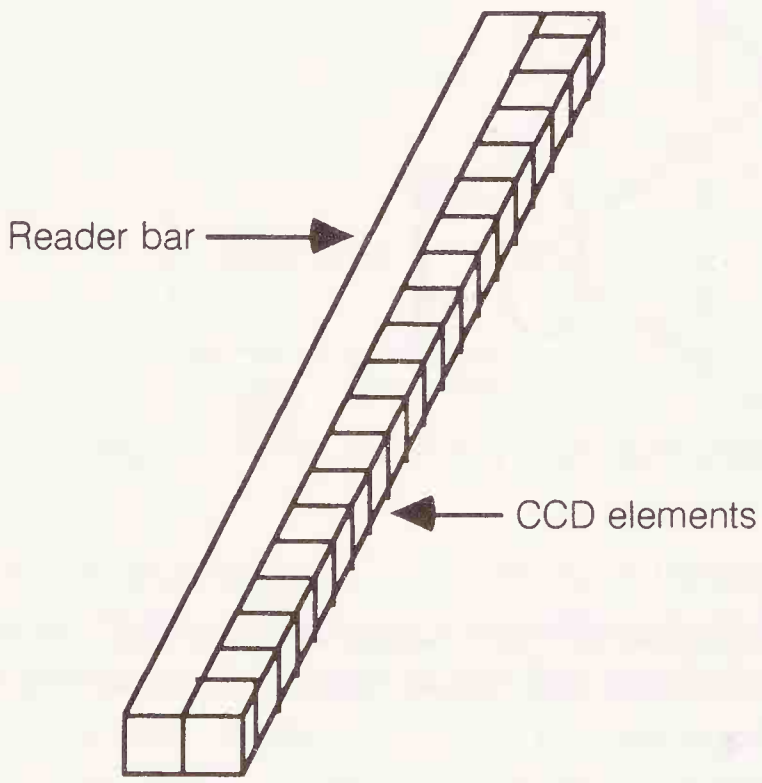


Fig. 2-5. A CCD reader bar contacts (or moves very close to) the paper and reads an entire line at once. No scanning mechanism is used.

During scanning, a precision stepper motor inches the paper past the scanning device. This stepper motor works in unison with the image scanning so that no streaks or smears exist in the final output. As shown in FIG. 2-6, the stepper motor operates a rubber roller, which feeds the paper through the machine. If the paper slips in the rollers, the scanning will be ruined and the transmitted image will be degraded. So, it is

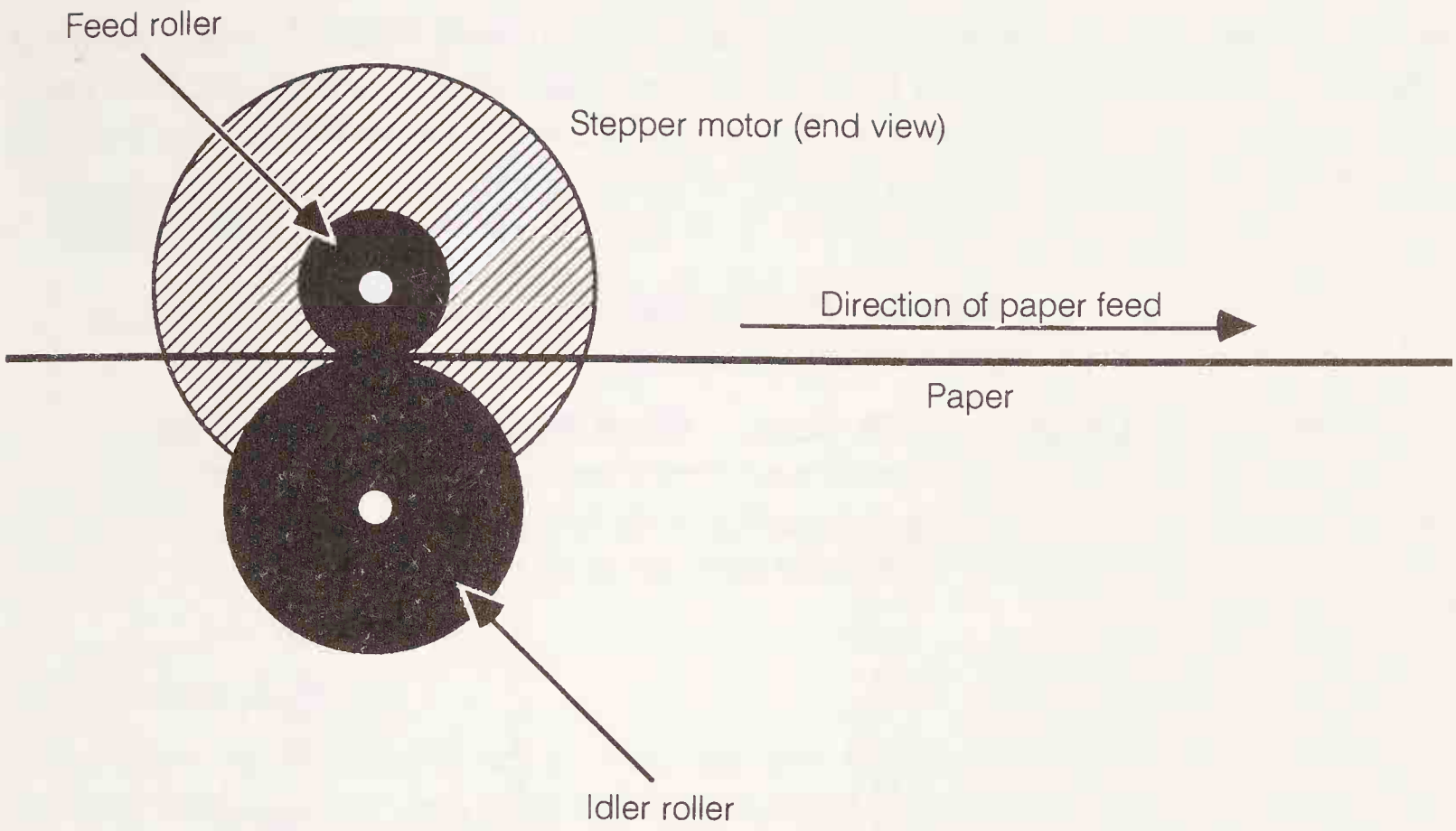


Fig. 2-6. The paper feed through a fax machine.

very important that the paper does not slip while feeding through the fax machine. Glossy or coated papers sometimes have this tendency.

Flat-bed fax machines lack a paper transport mechanism, because they are designed to scan a piece of paper that is flat on a glass plate. The only moving part is the scanner, which typically consists of a multi-CCD reader bar or array. Some high-end flat-bed fax machines also include an automatic document feeder that shuttles the paper onto the glass plate. After scanning is complete, the page is removed and another takes its place.

Image-digital conversion

During scanning, the fax rapidly converts the image to a digital format. The end-result is a series of 1s and 0s that represent the printed material on the page.

The sequence of digital data is not a simple matter of applying a "1" to the black areas on the page and a "0" to the white areas. At the standard resolution of a fax machine, which is approximately 20,000 dots per square inch, that equates to roughly 1,870,000 binary data bits per page. With so much data to transmit from one point to the next, even with high speed communications, the fax would need over three minutes to send one page.

Rather, the fax machine analyzes the image so that the digital data can be compressed into smaller chunks. The compression technique used in all Group 3 fax machines is called *modified Huffman run-length encoding. Huffman encoding* is a standard in the computing and data communications industry. It works by exchanging the most commonly occurring data with abbreviated codes. Data that occurs less frequently is assigned a longer code. The overall effect is a net compression of data.

Huffman encoding is ideal for character-based communications, like sending text from one computer to another. By itself, it has limited appeal to fax machines. To make

the technique more usable, Huffman encoding is combined with *run-length encoding*. The most common sequences of black and white image patterns are assigned the shortest codes. TABLE 2-1 shows the first 20 modified Huffman codes for sending a repeating pattern of white or black dots.

Table 2-1. First 20 Huffman Codes.

White Run Length	Code Word	Black Run Length	Code Word
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	0000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	001100	19	00001100111
20	0001000	20	00001101000

Notice that, overall, the codes for white dots (blank areas) are shorter than the codes for black dots (printed areas). The average double-spaced type document is about six percent text; the rest is white space. The modified Huffman encoding technique is based on this theory, using shorter codes for the more commonly encountered white areas of the page.

Once the image has been compressed and converted to digital form, it is stored temporarily in RAM (FIG. 2-7). The transmitting fax machine might scan and convert 25 percent or more of the document before the data is actually transmitted to the receiving fax. The RAM ensures that no data is lost in case the receiving fax is held up.

The RAM is also used to hold data in case it needs to be retransmitted. This can sometimes occur when the phone line is noisy and the receiving fax returns a command to resend the data. Because one or more lines of data are stored in memory, the transmitting fax can readily resend it without having to physically back up the page. Doing so would cause even more errors. Error detection and correction are covered later in this chapter.

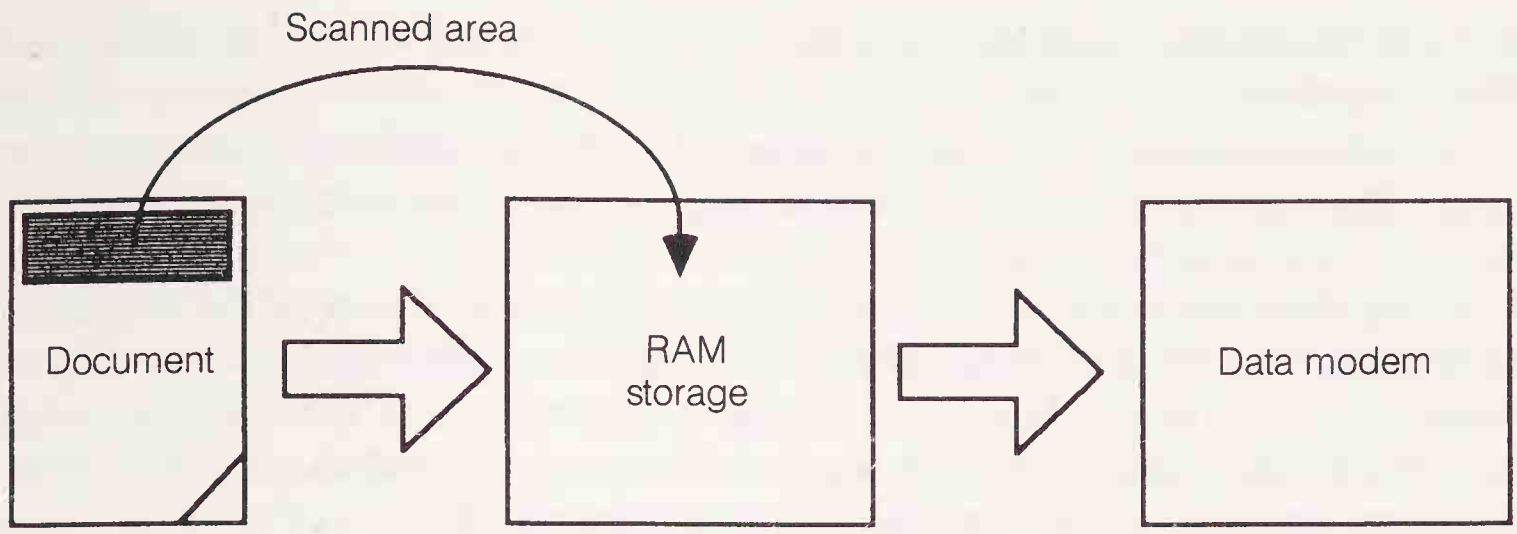


Fig. 2-7. Random-access memory (RAM) is used to store data before transmitting the document. It is also used to store portions of the document in the receiving fax.

Data transmission

Phone lines are designed to carry sound, not data signals. In order to transmit the fax over long distances, the data must first be converted to audible tones. Fax machines use an almost identical telephone transmission system as modems for computer data. Both fax modems and computer modems transform electrical signals into audible tones. Electrical signals are modulated into audible tones for sending through phone lines and the tones are demodulated back into electrical signals at the other end (see FIG. 2-8).

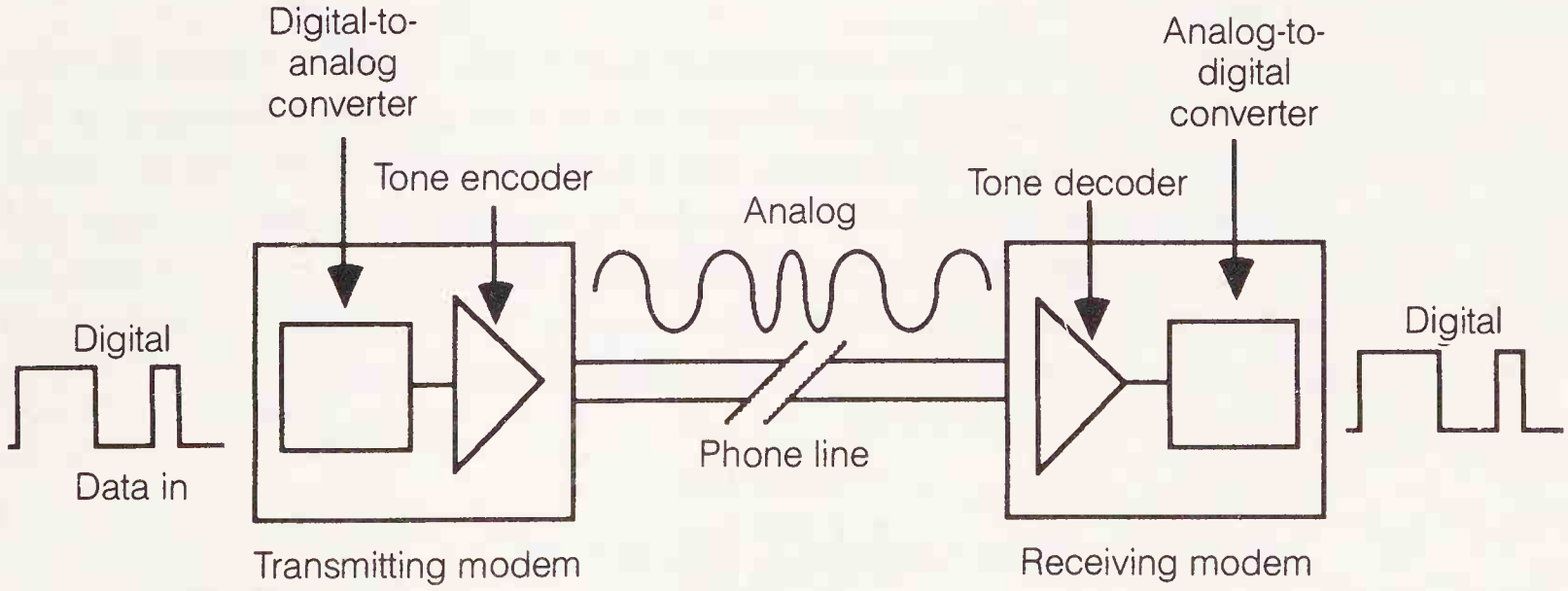


Fig. 2-8. The operation of a telephone modem. The modem is the component of a fax machine that actually sends the document information through the phone lines.

Modem speed is directly related to the number of times the tones can be altered in one second. Changing the tones 300 times per second provides a modem speed of 300 bps. Conversely, changing the tones 600 times per second provides a modem speed of 600 bps.

Things get tricky at faster transmission speeds because the ordinary telephone line can only handle frequencies between about 300 and 3,000 Hertz (Hz). The resulting

2,700 Hz bandwidth means that the phone line can't carry a signal that changes faster than 2,700 times per second.

Modems that operate at 1,200 bps or faster break the transmission into two or more groups. Each group is overlapped or superimposed over the others, then sent through the phone line simultaneously.

Group 3 fax machines use modems that operate at speeds up to 9,600 bps. Listen to the sound the fax makes and you'll hear a constant tone, plus additional warbling tones during the transmission. The constant tone is a carrier wave, like the broadcast frequency of a radio station. Data is transferred from one modem to another by altering the instantaneous amplitude and phase of this carrier tone.

- Instantaneous amplitude is the strength (or volume) of the signal.
- Phase is the orientation of the carrier signal, with respect to an arbitrary starting point. You can best imagine signal phase as the numerals on the face of a clock. Each number denotes a different phase, starting from the 12 o'clock position.

An important note: I've been using the term *bps* intentionally, rather than the often-used (but misapplied) *baud*. Though the two terms are often used interchangeably, they are not synonymous. For the sake of clarity, *bits per second* is the total number of data bits that are transmitted in one second; *baud* is the total number of state (or tone) changes in one second. The modems used in faxes send and receive data at a rate of 9,600 bits per second, but they do so by changing their state (or tone) no more than 2,400 times per second.

An understanding of the way fax machines transmit data by way of tones through telephone lines helps you appreciate the complexity of the process. Obviously, if the sound quality of the phone lines is marginal, the modems might not be able to "hear" one another. This causes an increase in the number of errors (transmission errors, and what causes them, is explained later in this chapter). All Group 3 fax machines are designed so that they will reduce the transmission speed by predetermined steps, until communications can proceed without constant errors. These steps are:

- 9,600 bps
- 7,200 bps
- 4,800 bps
- 2,400 bps

Receiving a document

In many ways, receiving a fax document is the reverse process of sending one. The major difference is that receiving a fax, the document is printed; when sending a fax, the original is scanned.

Data reception

The first step in receiving a fax is converting the audible tones heard through the phone line into digital impulses. Once again, this is the domain of the modem built into the fax

machine. The modem at the receive end demodulates the tones into binary 1s and 0s. The most important requirement of the receiving modem is that it must operate at the same speed as the sending modem. Otherwise, communications cannot occur.

Fax machines employ a sophisticated "seeking" or training procedure so that transmitting and receiving faxes can eventually lock on to one another:

Digital conversion Again, the digital conversion in the receiving fax is the inverse of what occurs in the sending machine. The digital 1s and 0s are converted to white and black image areas.

Printing Once the data is converted, it can be printed. Most fax machines use thermoreactive printing. Although the technique might vary somewhat from machine to machine, the basic idea is the same.

A single strip contains 1,728 tiny embedded heat-producing elements (FIG. 2-9), called the *printhead* (also called the *print bar*). Each heat-producing element is controlled individually. As the paper passes under the printhead, various printing elements are charged with electricity, so they become hot. The heat causes the paper to turn black, thereby producing an image on the page.

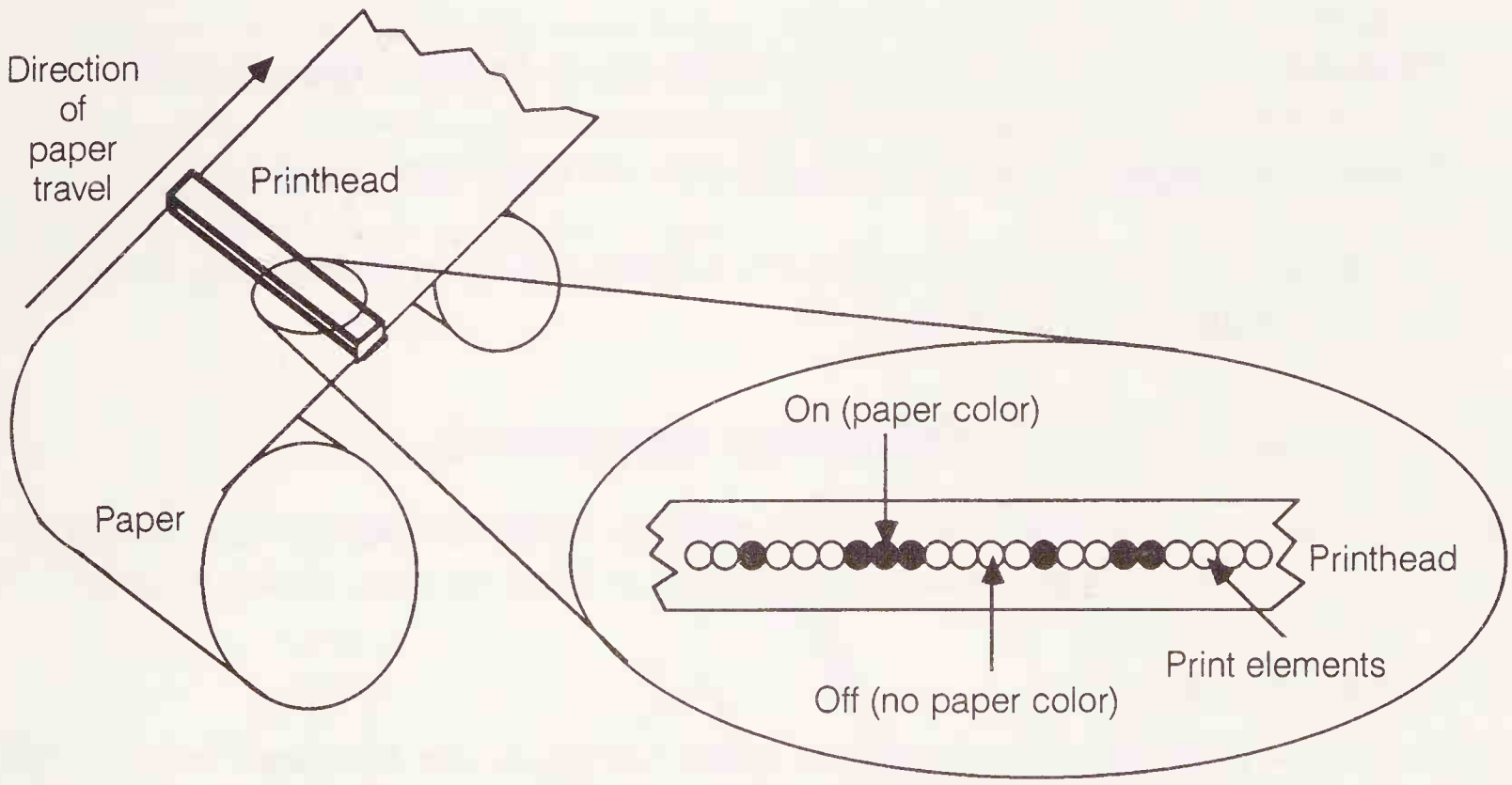


Fig. 2-9. How a printhead works.

For every black area on the page, heat is applied by the printhead. The heat is turned off for the white areas.

The thermal paper, called the *recording* or *receiving paper* used in fax machines is composed of several layers, as shown in FIG. 2-10. The bulk of the paper is a smooth white base. On the top (image) side of the paper is the color-producing layer, which consists of several ingredients:

Base Regular smooth bond paper.

Color-forming layer The image-making portion of the paper, placed on one side of the sheet only. This part turns black or gray.

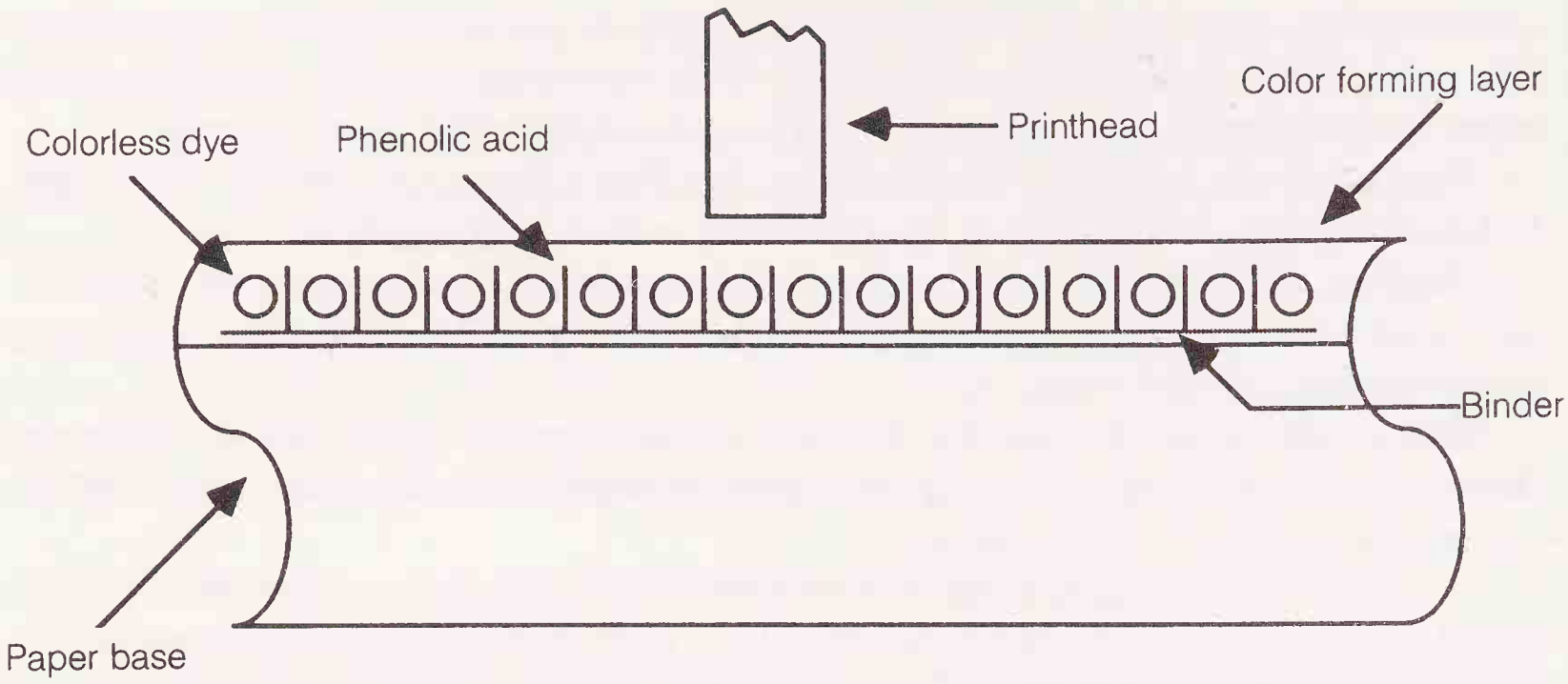


Fig. 2-10. An enlarged, side view of thermal paper, which is used in modern fax machines.

Colorless dye A dye that is colorless in its normal state, but can darken under a chemical change.

Phenolic acid A developer chemical that reacts to heat. When heated, the phenolic acid cause the colorless dye to darken.

Binder Holds all the ingredients in the color-forming layer together.

Fax paper is also often coated with a thin lubricant to aid in transporting the sheets smoothly through the fax machine.

Plain-paper fax: a different approach

So-called plain-paper fax machines use one of two printing technologies that are different than the regular thermoreactive printing that is found on most Group 3 models.

Thermal transfer

Instead of the printhead directly heating sensitized paper, the printhead melts an ink ribbon, which in turn imparts color to the paper. The printing technique is still thermoreactive, but the fax is designed to work with a ribbon spool.

Many thermal-transfer fax machines can also use both methods: print with a ribbon and print directly on sensitized paper.

The paper used in thermal transfer fax machines isn't really "plain." To achieve best results, you need to use a smooth, coated paper. The ink from the thermal-transfer ribbon doesn't adhere well to regular bond or cotton-content paper.

Xerographic

Xerography, dry writing, is the generic term for photocopying onto plain paper (copier giant Xerox takes its name from the print-making process). The printing technique is very similar to the kind used in laser printers and plain-paper copiers. These fax machines, generally suited for the very busy corporate environment, are designed for

high volume. They use cut sheets—in reality, copier paper. They accept most any kind of paper, within the design restrictions of the machine. You can often use letterhead, envelopes, card stock (up to 35 pound), overhead transparencies, you name it.

Xerography can trace its roots back to 1907, when the Rectigraph Company of Rochester, NY (home of Eastman Kodak), announced and patented the Rectigraph photocopying machine. The device, invented by George C. Beidler, was created out of a need to quickly and accurately reproduce legal documents. Beidler got the idea for the copier while he was a clerk in the Oklahoma City land-claim office.

The Rectigraph was a crude form of photography which produced large page-sized prints. In 1937, the same year that the first jet engine was built and the Golden Gate bridge opened, Chester Carlson conceived the idea for xerography, a photocopying technique that would use electrical charges and dry powder. The xerographic process required many years to perfect, but by the 1960s, plain-paper copiers were becoming commonplace.

The technology for plain-paper copiers is highly versatile, so it is suitable for other document-printing requirements. The process is ideal for high-resolution laser printers, for example. It's also perfect for high-end, high-volume fax machines.

Such fax machines are the same as any other Group 3 model, but they differ in the printing engine, shown diagrammatically in FIG. 2-11. The plain-paper printing engine works by directing a laser against the surface of a photosensitive drum. This drum carries a high-voltage charge. Light that hits the drum alters the charge, so the drum carries an electrified duplicate of the original.

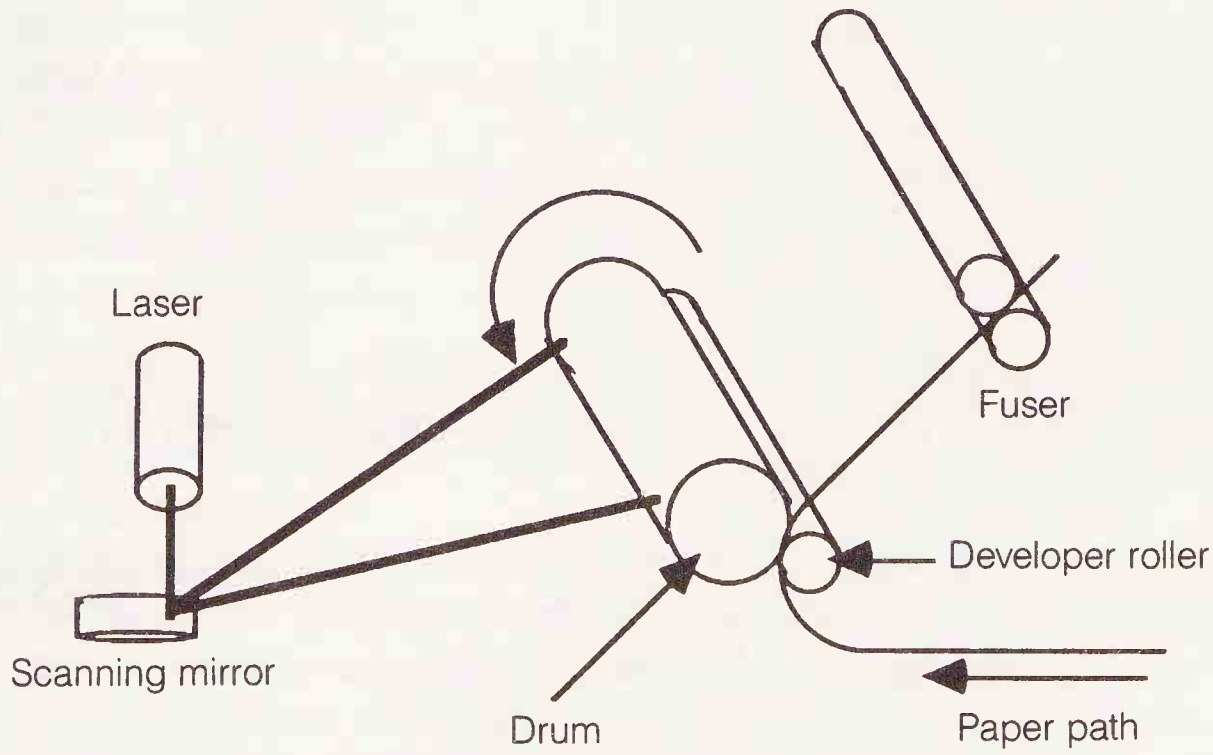


Fig. 2-11. Plain-paper xerography process.

The charge either repels or attracts a fine-grain powder, the *toner*. Toner sticks to wherever the light was. This technique corresponds to the writing or printing on the original faxed document. A piece of paper is then brought into contact with the drum and the toner is transferred to the paper. The dry toner is then fixed to the paper by a heater element, the *fuser*.

Sequence of events

The transmission and reception of a fax document occurs in phases. Each phase must be completed in turn before the next can occur. A problem in any phase can mean that the document is not transmitted or received properly, and an error can result.

The following is the sequence that is required for each facsimile transmission (see also FIG. 2-12 for a visual representation). For the sake of clarity, consider the initiator of the call—the transmitter. The remote fax is the receiver. It is possible, but not normal, for a fax machine to initiate the call, then receive a document.

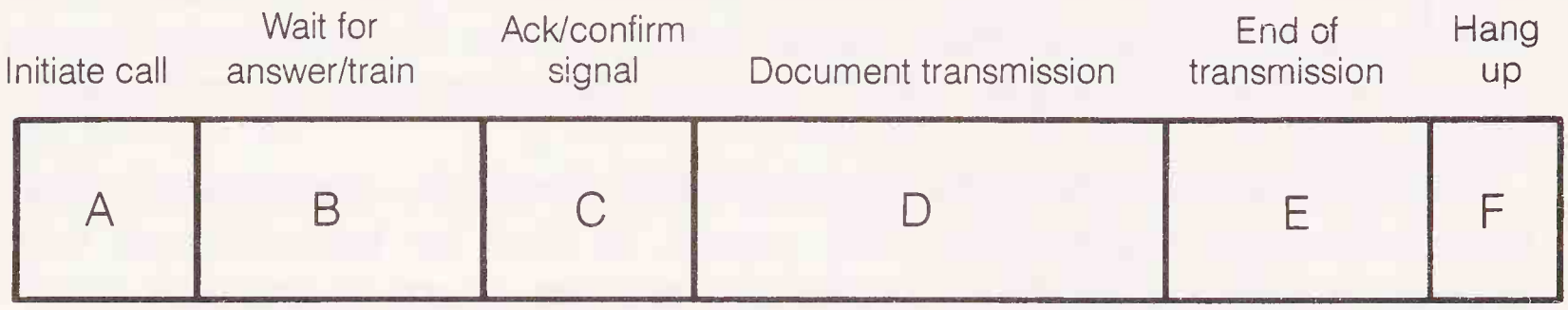


Fig. 2-12. The calling sequence of a fax transmission.

1. Initiate call. The sending fax dials the phone number that you provided.
2. Wait for the answer and training sequence. The sending fax does not automatically assume that the phone will be answered by a fax machine ready to receive a document. The sending fax listens for call completion (phone rings, busy signals, etc., are detected by circuitry in the fax). Once the line is established, the transmitting fax sends a training sequence to establish a connection with the remote machine. The training sequence consists of short tone bursts in an effort to establish carrier-tone detection, timing synchronization, and other communications factors.
3. Acknowledge/confirmation signal. If all is well, the receiver trains successfully and acknowledges that it is ready to receive data. The receiver sends a confirmation signal to the sender.
4. Document transmission. The document is transmitted from the sender to the receiver. These communications are actually two-way: the sender transmits the document and the receiver continually acknowledges receipt of data. If a transmission error occurs, the receiving fax notifies the sender and requests the data to be retransmitted. This process continues until the entire document is sent.
5. End of transmission. At the completion of the document, the transmitting fax sends an end-of-transmission signal. This signal lets the receiving machine know that no additional data will be sent.
6. Hang up. The sending and receiving fax machines hang up the phone, thus terminating the link.

The extra phases require time, so a one-page document takes longer than the advertised 18 seconds or so for Group 3 transmission. The sending fax must first establish the call and communicate with the receiving machine. This alone might last 10 to 20 seconds. Only then can the actual document be transferred. Assuming that the phone line is free from serious defects (such as noise or echo), the machines can communicate at top speed and transmit documents in the Group 3 standard of about 18 seconds per page.

In addition to the overall transmission/reception sequence, the sending and receiving fax machines perform other functions.

- On fax machines with an automatic document feeder (ADF), the sending fax will feed the individual pages through the machine if the document consists of two or more sheets.
- The sending fax will indicate the end of each page, allowing the receiving fax to cut the sheets from the paper roll, as needed. The end of page code is always sent, even if the receiving fax lacks a paper cutter.
- The sending and receiving machines provide communication and transmission status through indicator lights or an LCD panel.
- Details about the transmission or reception are recorded in a journal (not all fax machines keep a transmission log, but most do). These details include: time and date of the transmission, number of pages sent, and relevant comments or error messages.

Error detection and correction

Inserted in the data are *parity bits*, which are used to detect errors. These parity bits are tagged to the data during the transmission process. The sending fax uses a mathematical formula to determine the proper setting of the parity bits, in relation to the transmitted data. The receiving fax, in turn, analyzes the received data, compares it to the parity bits, and determines if a probable error occurred. When errors are detected, the receiving fax will either attempt to reconstruct the data or request the transmitting fax to re-send the corrupted data.

The frequency of errors determines the overall throughput of the fax machine. *Throughput* is the actual amount of valid data that is transmitted to the receiver, and affects how many pages actually get sent during a certain time frame.

With no errors, the fax can operate at full throttle, sending bits as fast as the receiving machine can digest them. Conversely, with errors, data must be sent over and over again, until the entire document arrives intact. In the case of severe errors, the received document will contain smears and blips. In extreme cases, fax machines might disconnect from the line when data transmission proves impossible.

Communications errors can be caused by a number of factors; the most troublesome is *line impairments*, the catch-all phrase for the quality of the phone connection. Line impairments take many forms; if more impairments disrupt the line, more errors

will occur. So, line impairments slow data transmission. The most common line impairments are echo, phase jitter, white noise, noise hits, drop out, and signal loss.

- Echo is when the fax on the receiving end gets the real transmitted data, along with delayed and distorted reflections of the original signal. Echo is the most common and the most damaging impairment. Fortunately, it's also actively attacked by fax manufacturers. As a result, most Group 3 fax machines incorporate significant circuitry to battle the side-effects of echo.
- To understand *phase jitter*, imagine dropping a small rock in the water of a calm lake. Small waves radiate outward from the point of impact. Now, throw another rock in the water and watch those first waves as they become jumbled with the waves from the second rock. Phase jitter in a fax signal is the same. Interference from outside sources (like the 60-Hz current that flows through your house or office) can interrupt the signals that compose data transmission through your fax; these interruptions could cause jumbled data. As with echo, fax machine electronics detect and compensate for the effects of phase jitter.
- *White noise* is simply the background hiss you hear on most any phone line. The higher the noise, the harder it is for the modem to latch onto the transmitted data. Most modern Group 3 fax machines are hearty challengers to phone line noise, continuing to send data (although sometimes at slower transmission speeds because of error detection and resends) far beyond what even the phone company would accept as a minimum-quality phone connection.
- *Noise hits* are periodic loud bursts of noise, normally caused by instantaneous interference by some electrical discharge, like a nearby laser printing that is turned on, or the crackle of lightning from an electrical storm somewhere along the path of transmission. Noise hits generally mask the original data completely, but because they are random and short-lived, fax machines compensate by resending the data.
- Periodic lulls in the volume of the sound passing through the phone line is a *drop out*. Most drop outs last only a few hundredths of a second, but at 9,600 bps speeds, over 100 bits of information could be lost. As with noise hits, fax machines compensate for drop outs by resending the shuffled data.
- *Signal loss* is a constant decrease in the volume of the sound. Engineers generally refer to signal loss as *attenuation*, which means "thin" or "dilute." Attenuation causes line impairments to appear louder, with respect to the fax signal. Most Group 3 faxes actively boost and filter the incoming sound of a distant modem to counter the effects of attenuation.

Group 3 fax specifications

You'd be surprised how many "features" of modern fax machines are actually part of the Group 3 fax specification. Among the specifications are transmission speed, mini-

mum paper sizes, resolution, and more. Although the Group 3 specifications are quite involved, TABLE 2-2 lists the more important standards.

Table 2-2. Group 3 Fax Standards.

Picture elements per scan line	1,728
Normal time per page	1 minute (varies with contents of page)
Total scan lines	8.46 inches (215mm)
Scan density	97.8 lines/inch (3.85 lines/mm), normal resolution; 195.6 lines/inch (7.7 lines/mm), fine resolution
Coding scheme	1 dimension standard: modified Huffman code 2 dimension option: modified READ code
Modem	Standard: 2,400 and 4,800 bits per second, CCITT V.27 ter Optional: 7,200 and 9,600 bits per second, CCITT V.29

The well-equipped fax

Not every fax machine has every feature. Faxes can be portable manual-control machines to complex do-everything behemoths. Your fax machine might fall in the middle: it has a number of convenience features, but it isn't replete with bells and whistles.

Resolution selection Group 3 fax machines have two standard resolution settings, stated in dots or lines per inch (horizontal by vertical):

- Standard: 203 × 98
- Fine: 203 × 196

In addition, many fax machines have a third super-fine resolution of 203 × 391 dots per inch.

A quick look at the specifications shows that the horizontal resolution never changes. The reason is obvious: the horizontal resolution is fixed by the scanning and printing technology. All Group 3 transmission resolutions are 203 horizontal dots per inch.

By slowing the paper movement through the machine, it's possible to increase the vertical resolution, as shown in FIG. 2-13. Since the paper is moving more slowly through the fax at the higher resolution setting, the throughput (number of pages per minute) isn't as high. Most fax makers specify throughput at the standard resolution. You can expect a 50 percent increase in transmission times at the fine resolution, and another 50 percent at super-fine resolution.

Gray scale Fax technology isn't limited just to creating black and white prints. The electronic "eye" of a fax machine, the charged couple device (or CCD), is sensitive to levels of brightness. In addition, the thermoreactive printing technique can be used to create different shades. This process is called *gray scale* (or *half tone*) and it can be used to transmit drawings and photographs. Not all Group 3 fax machines include a gray-scale feature, but it is standard among most mid- and high-grade models.

Gray scale works by breaking down an image into discrete brightness levels, as

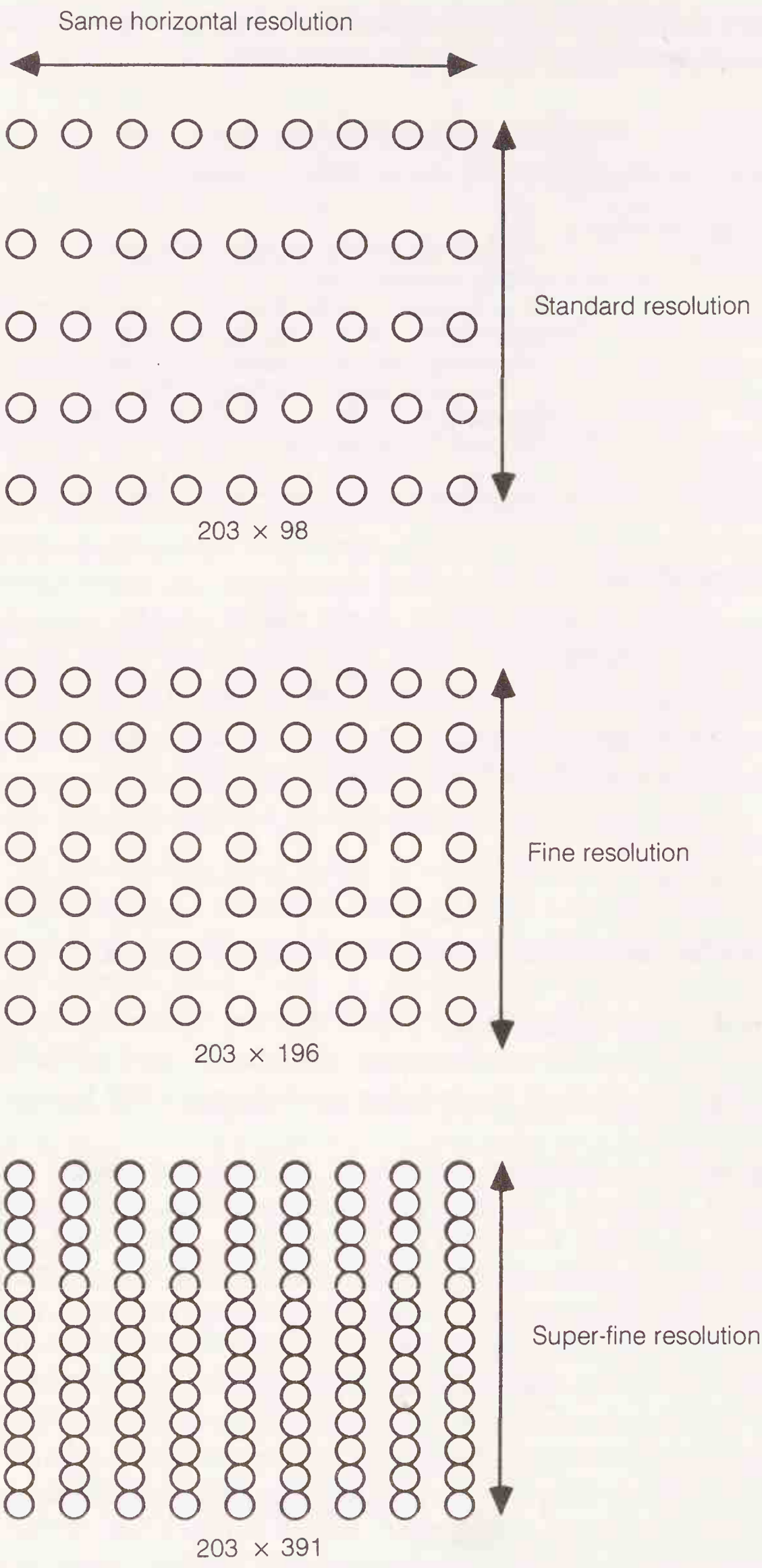


Fig. 2-13. On group 3 fax machines, horizontal resolution remains the same, but vertical resolution increases.

shown in FIG. 2-14. Fax machines can reproduce a continuous band of grays, but doing so would increase transmission times into the hours, not just minutes. The gray-scale approach is the next best thing. The gray-scale brightness levels apply to color and black and white images—the CCD in fax machines "sees" in black and white only.

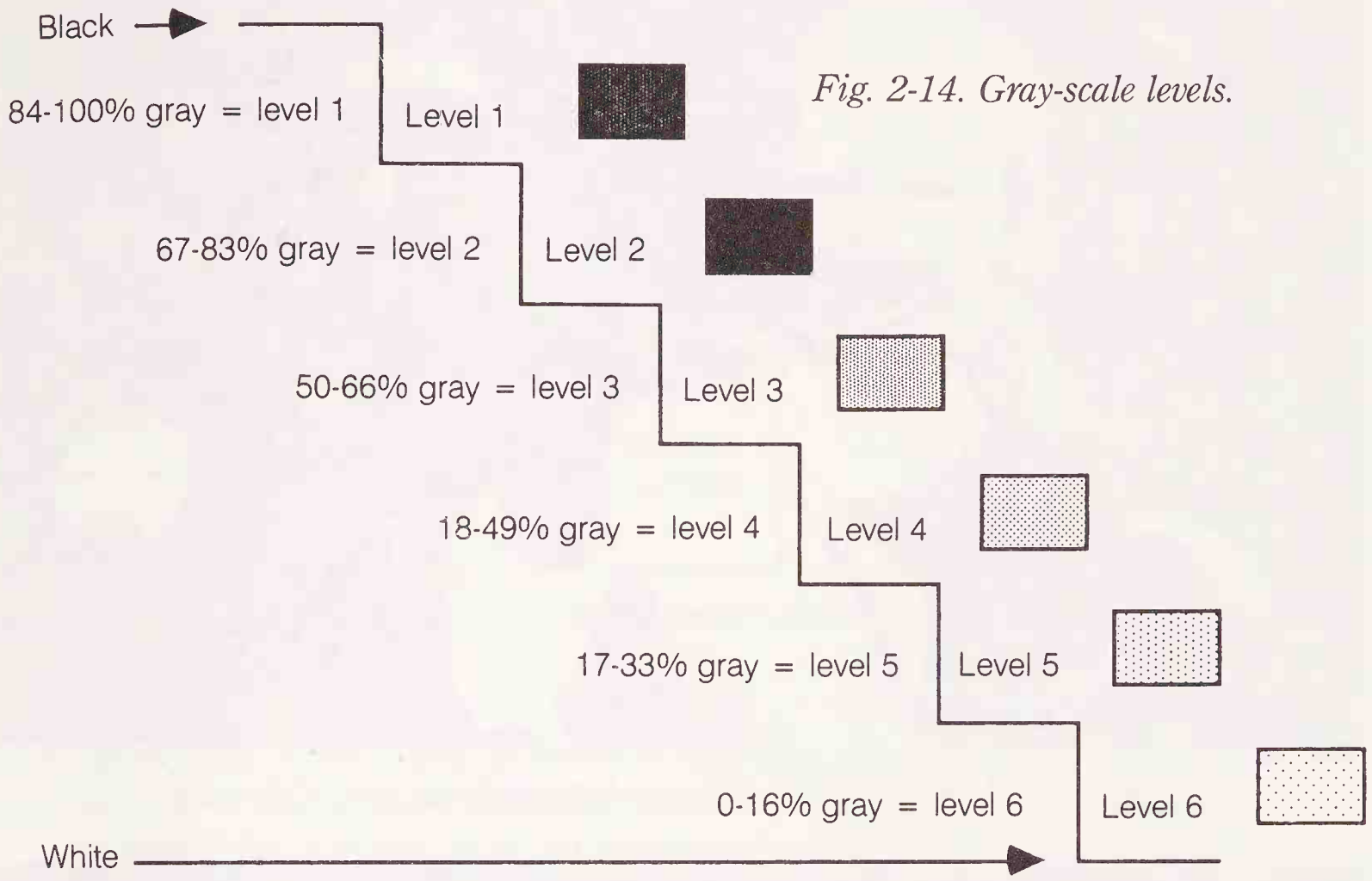


Fig. 2-14. Gray-scale levels.

Not all fax machines support the same number of gray-scale levels. One machine might handle up to 16 levels of gray, another up to 64. Obviously, the higher the number of gray levels, the closer the received document will look like a photograph. Of course, both the sending and receiving fax must share the same gray-scale capabilities.

During document scanning, the fax machine approximates the gray level of the original document. A particular measure of brightness that falls somewhere between two levels is considered to be at the lower level.

You'll want to use the gray-scale feature if you send lots of photographs. Figures 2-15 and 2-16 show a photograph transmitted in standard black/white mode, and gray-scale mode, respectively. Notice that the gray-scale test print has more detail and doesn't look as smudged.

Because gray-scale transmission is much slower, you'll want to limit the use of gray scale to only when you need it.

Phone dialing Most home and office fax machines include their own phone dialing circuits. These aren't any different than the kind you'd find in any piece of telephone equipment. As shown in FIG. 2-17, most fax machines incorporate a memory for retaining telephone numbers. Memory dial is available in two basic flavors:

- *Last number redial* Stores just the last number you called. Press the REDIAL key and the number is repeated for you.

Fig. 2-15. A test print of a sample photograph; no gray scale used.

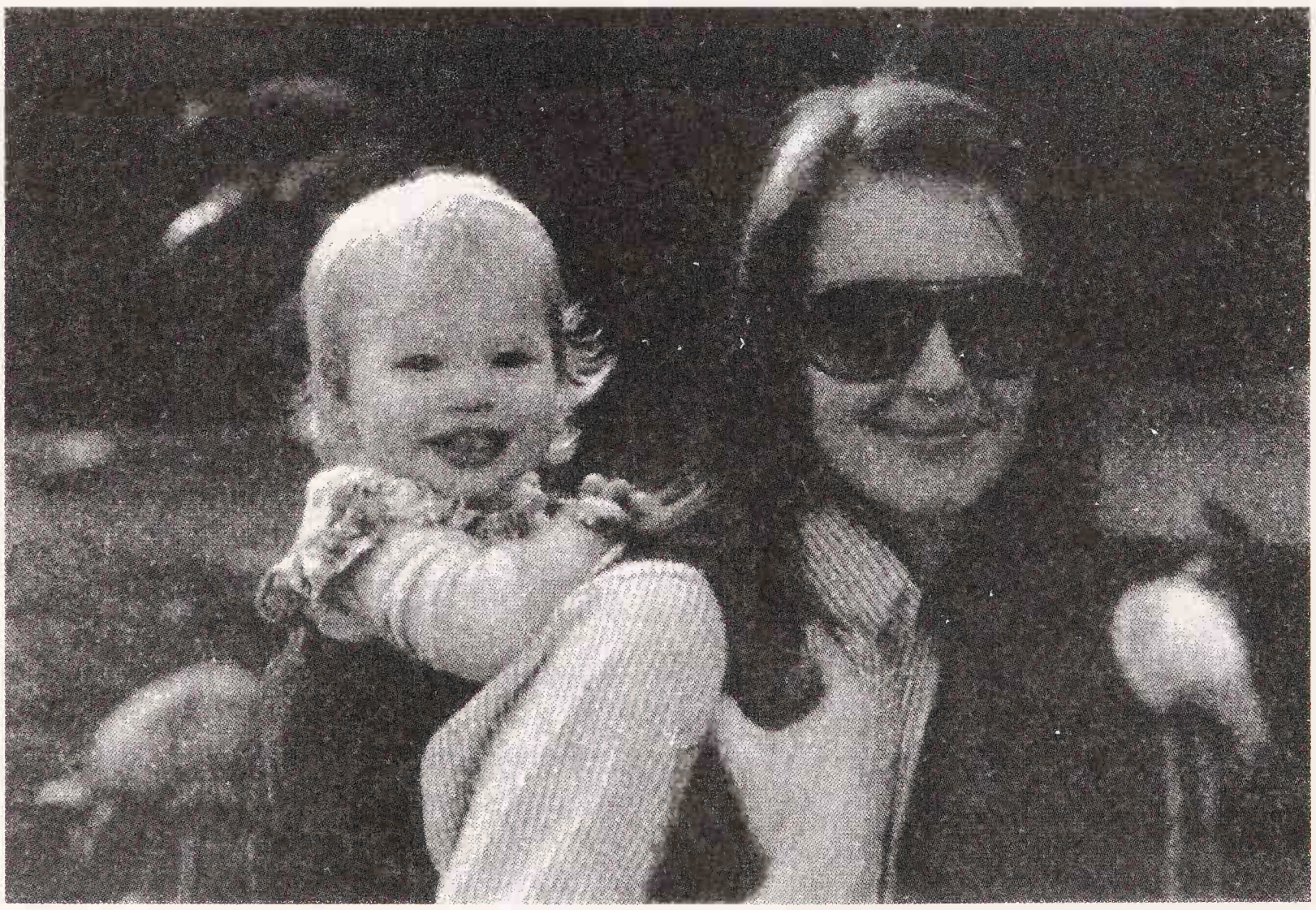


Fig. 2-16. A test print of a sample photograph 64-level gray scale used.

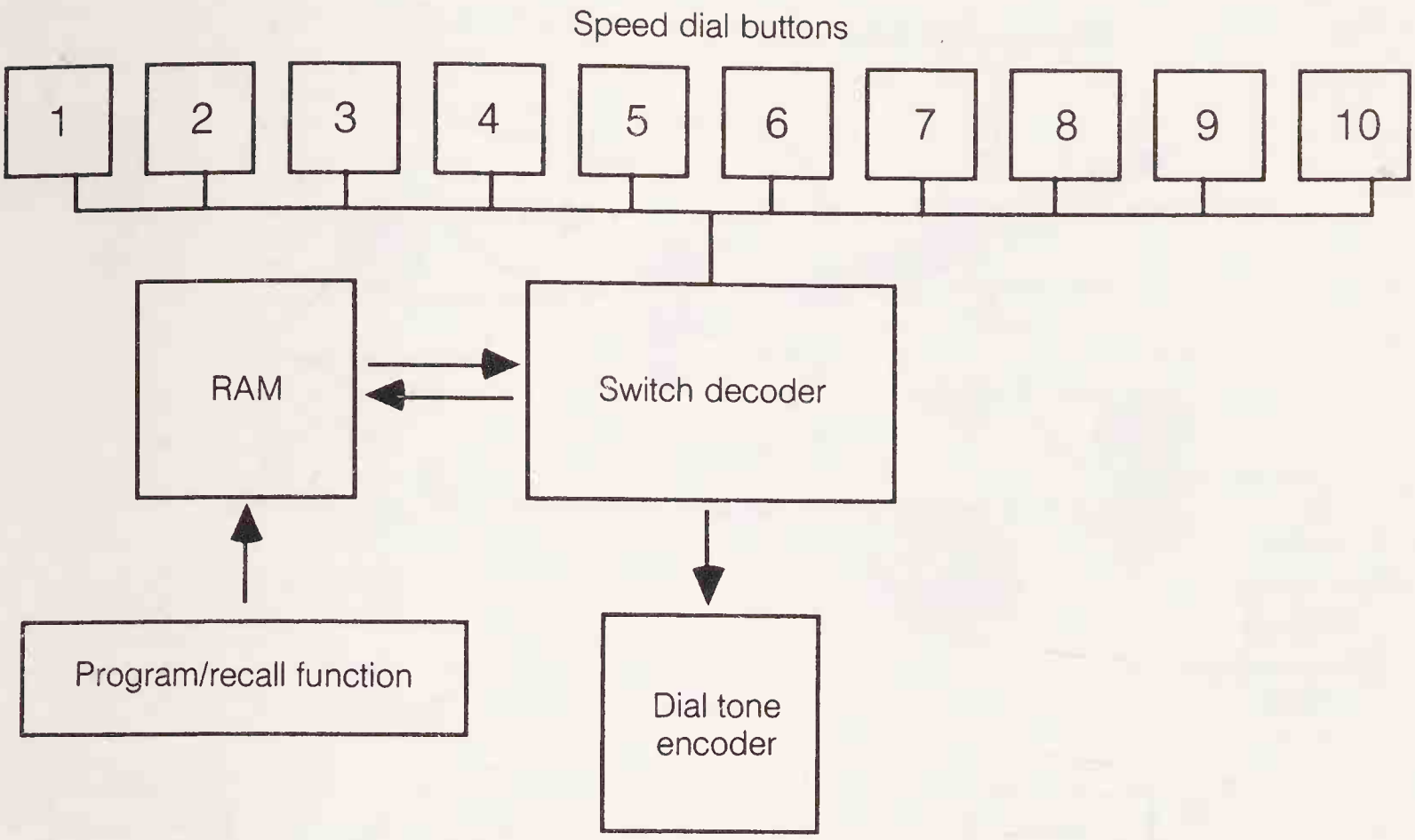


Fig. 2-17. How memory dial works.

- *Speed dial* Stores many numbers in long-term memory. Press a speed dial key and that number is quickly dialed for you. Many fax machines have two "tiers" of speed dial buttons: 10 or 20 quick-access that you can access by pressing a single key and 20 (or more) two-step numbers that require you to press several keys in succession.

Last number redial is temporary memory. Turn the fax off and the number is lost. Speed-dial numbers are held in long-term memory. The operating power for the memory is usually supplied by a battery. This battery lasts one year or so under normal conditions.

As detailed in chapter 5, it's always a good idea to periodically check the condition of the battery. Your fax machine will warn you when the battery is low, but you also need to visually check it every six months or so to be sure it is not leaking.

Automatic document feed The automatic document feeder (ADF) does exactly what its name implies: it automatically feeds individual sheets of a document into the fax machine. The ADF paper bin in most fax machines is limited to holding no more than about 15 to 20 sheets of paper, which should be suitable for most applications.

The ADF is composed of two main parts: a paper sensor switch and a feed mechanism. The typical ADF mechanism with a paper sensor switch is shown in FIG. 2-18.

The paper sensor switch tells the fax machine that sheets are waiting to be loaded in the ADF. This switch is typically a leaf-type, and it is triggered by the weight of the paper. Alternatively, some fax machines use an optical switch (FIG. 2-19) to detect when one or more sheets are present in the ADF bin. The optical switch works by infrared light: when the beam of infrared light is blocked, paper is in the ADF bin. When the beam is able to pass through to the sensor, no paper is present.

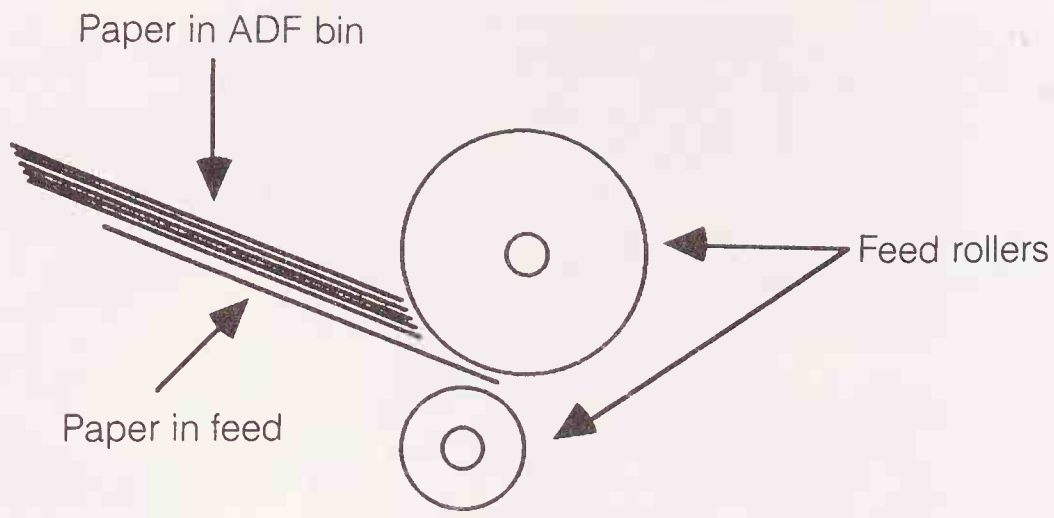


Fig. 2-18. The automatic document feeder (ADF) mechanism.

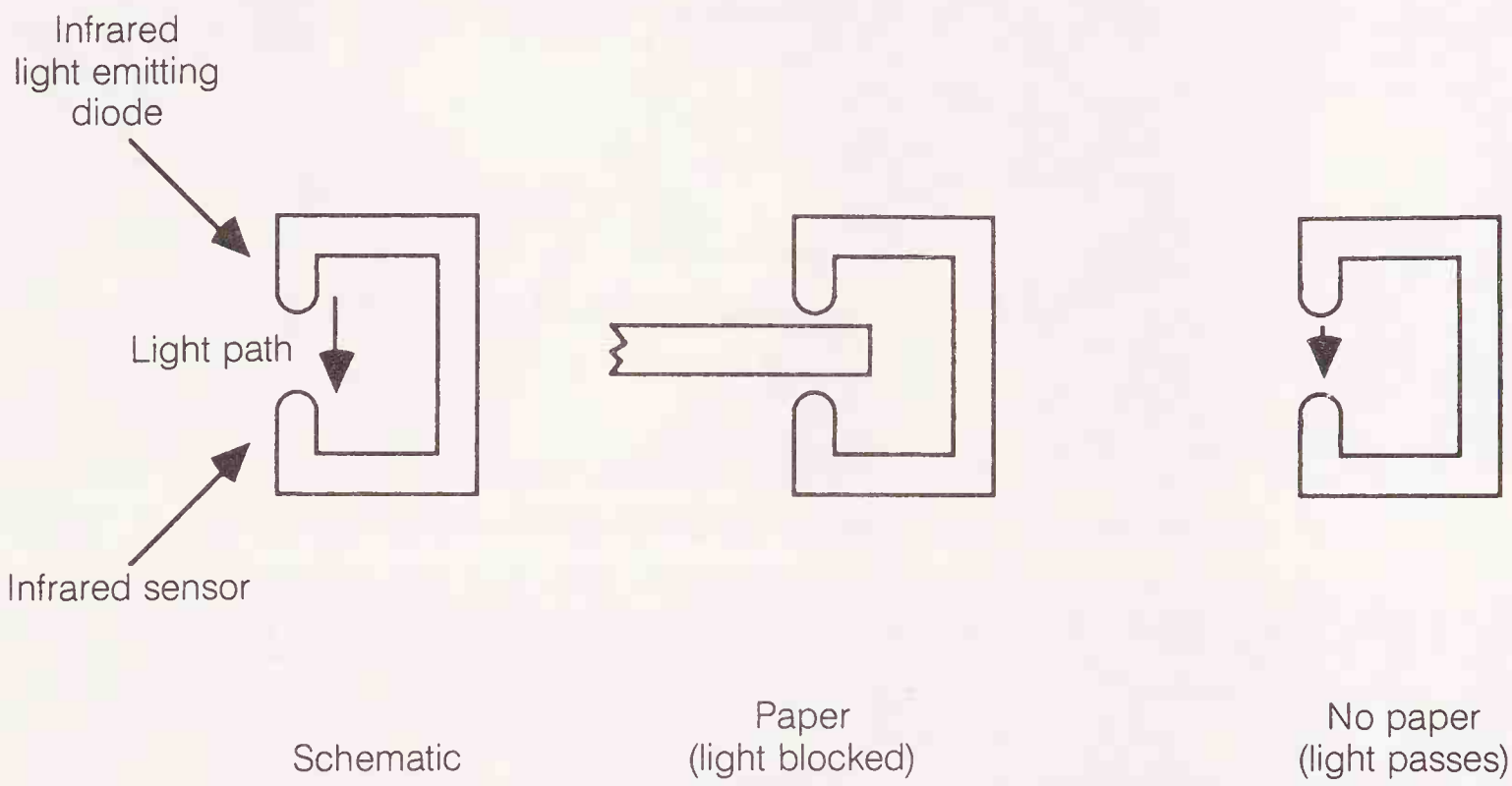


Fig. 2-19. Optical sensors in some ADF mechanisms detect when paper is loaded. Other fax machines use mechanical switches. Both are reliable, but optical sensors can get dirty.

The paper feed mechanism consists of a motor and rubber rollers. The motor turns the rollers, which inch the paper through the ADF. The mouth of the ADF bin and the rollers are designed so that they accept one sheet of paper only. Still, you must carefully position the pages in the ADF to ensure that all pages are inserted properly. This usually consists of separating the sheets in a stair-step fashion.

Paper transport and sensors Fax machines have two sets of paper transport mechanisms: one for the original page and one for the received page (except flat-bed models, which have a paper-feed mechanism for the received page only). The paper-feed mechanisms are shown in FIG. 2-20.

In many fax machines, the paper-fed mechanisms are operated from separate motors. In a few models, one motor operates both paper-feed mechanisms, and a clutch (magnetic or mechanical) engages the feed mechanisms.

Except for the low-cost models, fax machines incorporate various sensors to ensure that the paper is shuttled through the mechanism correctly. These sensors detect paper jams and empty paper-feed mechanisms. The sensors are typically the leaf-switch vari-

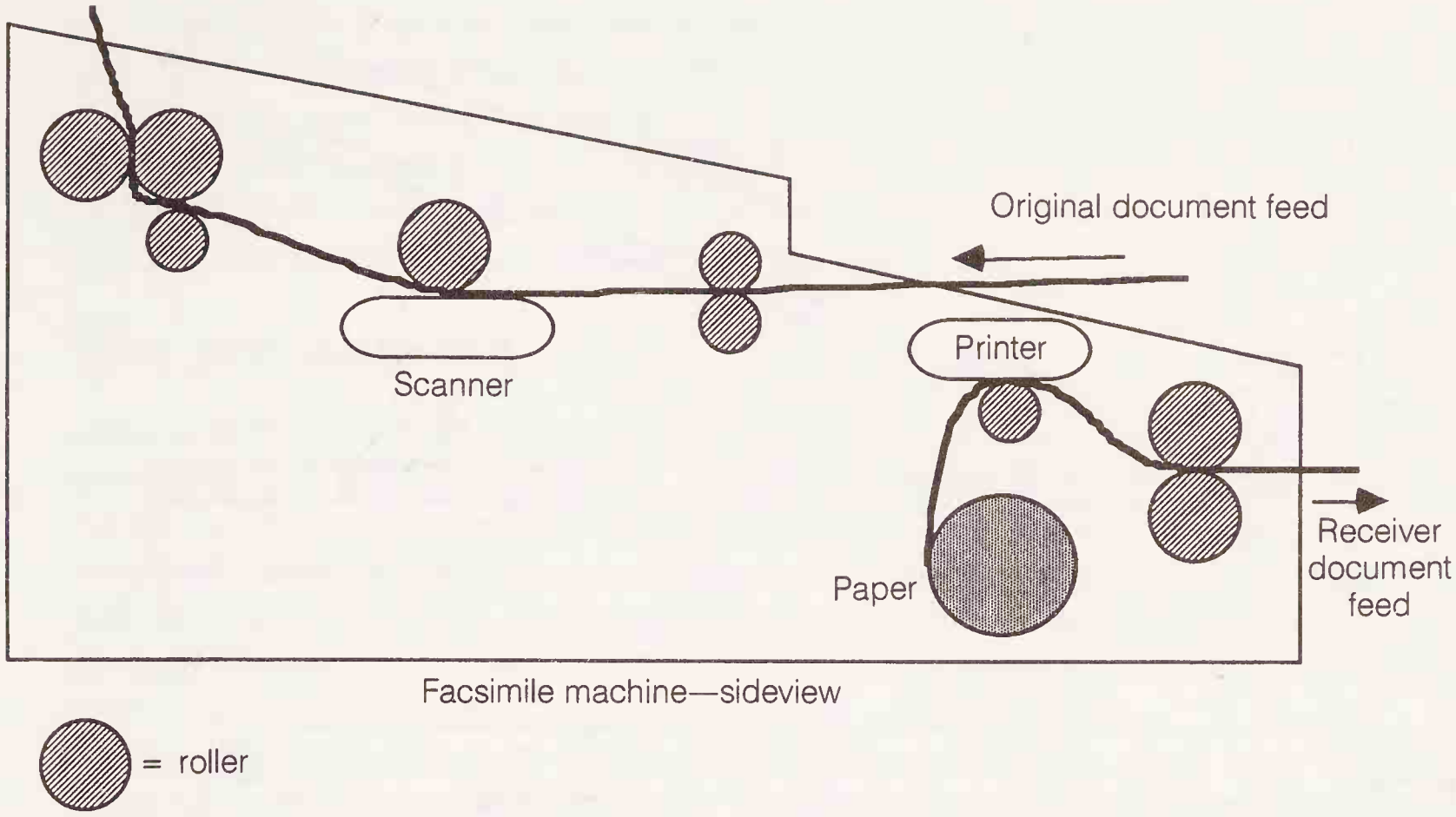


Fig. 2-20. The paper feed mechanism of the typical fax machine (side view).

ety. Occasionally, these switches become dirty or jammed, which can upset the operation of the fax. Chapter 8 shows how to test for dirty or jammed switches.

Automatic paper cutter Except for the low-cost models, most home and office fax machines have an automatic paper cutter to trim the received paper to size. The paper cutter is controlled by signals that are originally sent by the transmitting fax.

The automatic paper cutter is typically a guillotine knife that is operated by a solenoid (FIG. 2-21). When the solenoid is actuated by an electrical current, it draws down the knife of the paper cutter, which slices the paper.

Many fax machines incorporate self-sharpening steel blades in the paper cutter. This ensures long life without replacement or sharpening. However, after extremely heavy use, the paper cutter blades can become dull. In most cases, a service call is necessary to repair the paper cutter because it is not easily replaced and it requires alignment with special tools. These blades cannot be hand-sharpened.

Copier function Fax machines include a copy button that let you make a quick copy of a document. Insert the document into the document feeder, press COPY, and out comes a duplicate. The copy is created by first scanning the original, then printing the image onto the receiving paper.

The copier function also serves as a self-test. You will use it often throughout this book to test the condition and health of the machine.

Computer interface Many office-oriented fax machines are available with a computer data interface. These allow you to connect your fax machine to a computer and use it to send and receive documents. Special software is necessary for computer fax, but no special hardware is needed to link a fax to a computer. The data link is accomplished through the RS-232C serial interface, common equipment on most any PC. The PC-to-stand-alone fax machine link is shown in FIG. 2-22.

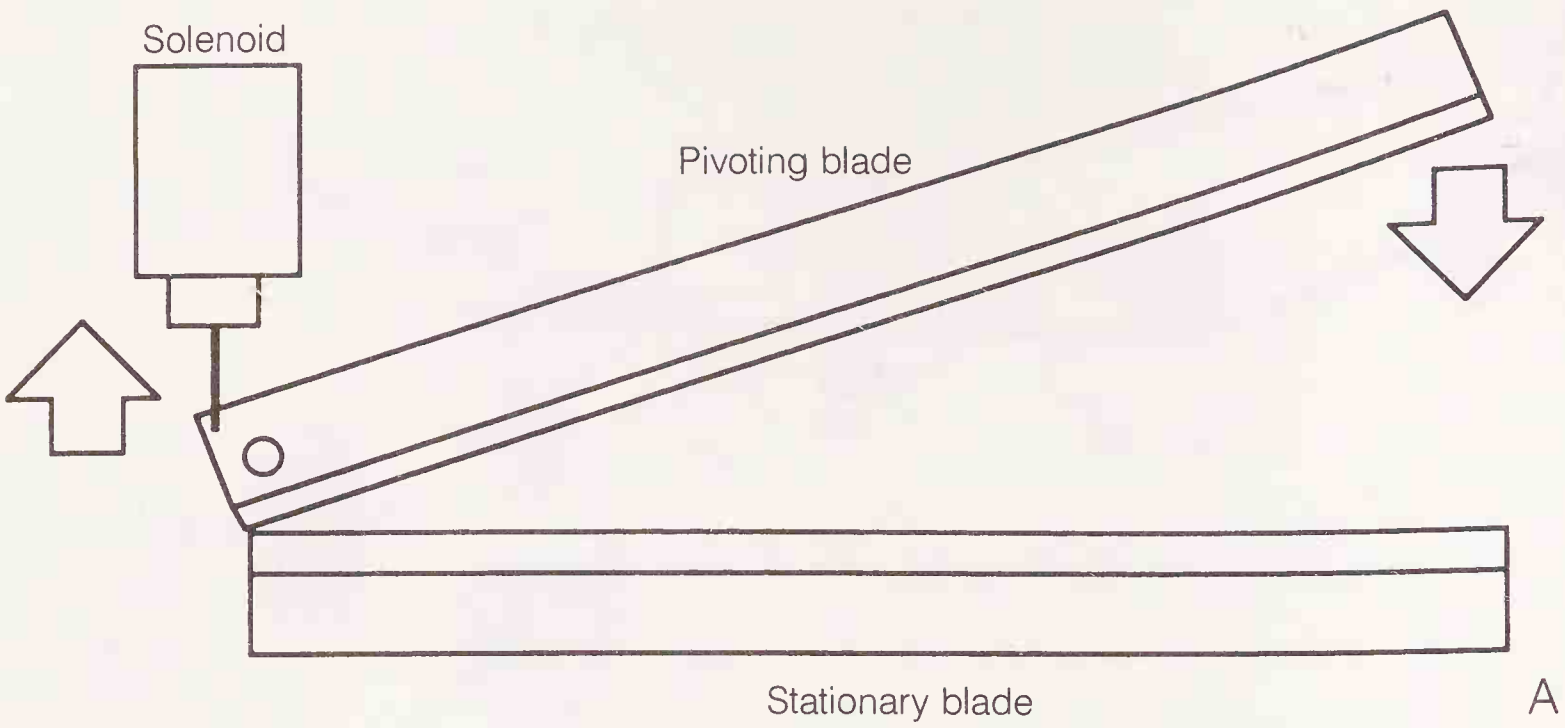


Fig. 2-21. Paper cutter action. An electrically-actuated solenoid moves the cutting blades. Several approaches are used: A. The moving blade is attached to a pivot and cuts the paper like scissors would; B. The moving blade is drawn over the paper from both sides (the cutting blade is usually at a slide angle).

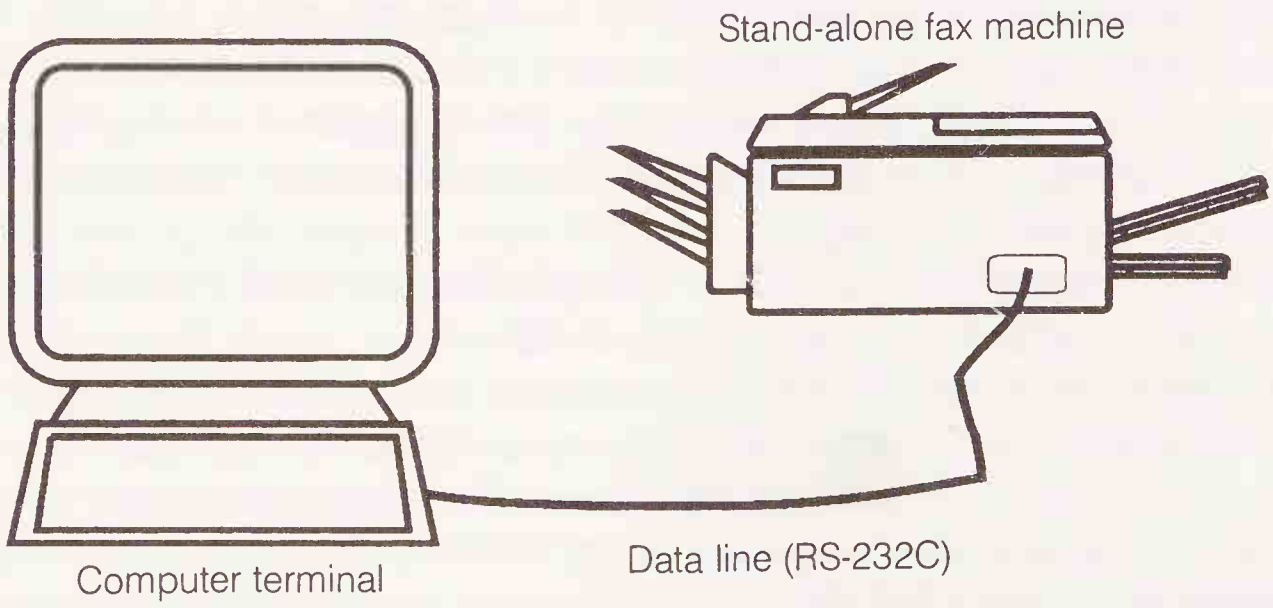


Fig. 2-22. The PC to stand-alone fax link is composed of a simple cable.

This setup is different than a computer that is equipped with a fax board. The computer-fax board combination turns a PC into a complete fax device. You can prepare documents in your computer and use software to convert them to a fax format. The board installed in your computer can then transmit it to another fax machine through the phone lines. Conversely, the PC to stand-alone fax link uses a computer to prepare the data, but it uses a regular fax machine to send it.

The portable fax

Once technology is developed for office equipment, it is invariably downsized for easy portability. It's true for computers, telephones, dictation recorders, and even fax machines. The portable facsimile is a complete fax machine that is trimmed to its basic essentials. It operates on battery or ac power, and it can easily connect to any telephone jack. With an optional accessory, you can even connect the portable fax to your cellular phone or to a pay phone. This connection requires an *acoustic coupler*—basically a set of rubber cups that is equipped with a speaker and a microphone.

Portable fax machines are convenient, but they don't have many fancy features, which helps to reduce possible mishaps. Because the machines are portable, they are subject to more abuse than the average office or home fax machine. So, these machines require a little more overall care and preventative maintenance. If you own a portable fax, be sure to read chapter 5 and chapter 6. These chapters are doubly important for you because of the extra dirt and grime that your fax machine can collect.

Duty handling

Duty handling is the number of faxes your machine is designed to send or receive in a month's time. By specifying duty handling, manufacturers can target models to appropriate markets and feel confident that a particular machine won't be overtaxed in a busy environment.

You'll want to pay close attention to the duty handling of your fax as it relates to its overall health. A fax that is designed to transmit and receive 500 pages per month is not suitable for an office that needs to work with 1,500 or 2,000 pages per month. Such overuse will lead to early failure of the machine, which will cause excessive downtime and service costs. Be sure you pick the right fax for the job.

Suggested duty handling will vary among manufacturers, but the following is a good rough estimate:

Model	Suggested Pages Per Month
Portable	150
Personal/home	300
Standard office	500
Heavy-duty office	1,000
Hub	1,500

Paper lengths

With the exception of xerographic-type plain-paper models, fax machines use continuous paper rolls. Fax paper is available in two widths: 8.5 and 10.1 inches, and four standard

roll lengths:

Roll Size/Feet	Roll Size/Meters	Number of Pages*
49	15	53
98	30	107
164	50	179
328	100	357

*Letter size sheets, each 8.5 × 11 inches.

The small 15- and 30-meter rolls are designed for portable and personal fax machines. The 100-meter rolls are used mostly by higher volume office machines and hub models. You should always use the size of paper that is designed for your machine. Avoid using 15- and 30-meter paper in machines made for larger rolls, or excessive curling and jamming could result.

3

The fax environment

Success with your facsimile machine depends on how well it is integrated with the rest of your office equipment. A haphazard arrangement will yield inferior results, and you won't be able to enjoy the full capabilities of the machine. Many potential problems can be completely avoided by proper fax placement and hookup.

If your fax machine is giving you problems, check this chapter first. It provides details on how to properly install, adjust, and use a fax. Facsimile isn't necessarily a difficult technology to use; on the contrary, it's quite simple. Nevertheless, a fax machine is unlike the trusty TV set—if you've never owned a fax before, you might be surprised by the special considerations that you need to remember.

This chapter also details some of the extras you can add to your fax setup to improve its operation and versatility.

Unpacking

If you have yet to buy or unpack your fax, here are some quick tips:

Concealed damage

When unpacking your fax machine look out for concealed damage. You can't see this breakage on the outside of the box, but it becomes apparent when you take the unit out of its shipping container. If the machine has been damaged, return it immediately to the dealer. Exterior damage is a good indication that internal components are also damaged.

Save the box and all packing materials—at least until you've had the machine one month or so. Most mechanical and electrical problems will arise in this time and you'll need the box to return the fax for warranty repair.

Check packing list

Most fax machines are available with a variety of accessories, including phone cables, power cables, paper, phone handsets, and automatic document feeders. Verify the

packing list against the contents of the box to make sure you have everything that you are entitled to receive. If you have purchased a portable fax machine, the unit might have a battery pack, a battery recharger and/or ac adapter, and a carrying case. Check the manual to be sure that the accessories are present. If any are missing, consult your dealer.

Installation

These tips are important when you install a fax machine:

Proper ventilation and the role of fax furniture

Fax machines generate a certain amount of internal heat, so avoid obstructing its ventilation slots. A machine that gets too hot will perform erratically or it might become damaged. Avoid placing the unit on the top of anything that gets warm, like a TV set, computer, laser printer, or other electronic device.

You should always place the fax machine on a level shelf or platform (desk or table) that's free of vibration and shock. Be sure that the shelf can adequately support the unit. If it looks as though the shelf might break under the weight of the machine, by all means, find another place to put it.

Fax machines that are equipped with a drop-off tray for the received paper will require a desk, table, or shelf that can accommodate the paper bin. A stand that is designed for computer printers often makes good fax machine furniture.

Hookup

Pay careful attention to how you hook up the pieces of your fax system. By using the right kind of cables, connectors, and accessories, and wiring everything properly the first time around, you're ensured of years of care-free operation.

Proper cords a must

To operate properly, your fax machine should use only approved telephone cords and connectors. These are available at most any electronics store, hardware stores, and telephone equipment outlets. You can purchase premade telephone extension cords in specific lengths (usually 3, 6, 10, 12, 15, and 25 feet) or you can make them yourself.

Sample phone cords are shown in FIG. 3-1. Notice that these cords are already equipped with RJ-type modulator connectors. These connectors are required when attaching the cord to the fax machine and to modern telephone outlets. If the outlets in your home or office do not use modular jacks, you'll need to purchase the proper adapters or install a new jack. Adapters and replacement outlets are available at most electronics stores and phone centers.

Telephone wire and connectors

When making your own telephone cords, be sure to use the proper two- or four-conductor cable, as well as the modular RJ-type connectors. These connectors are attached to

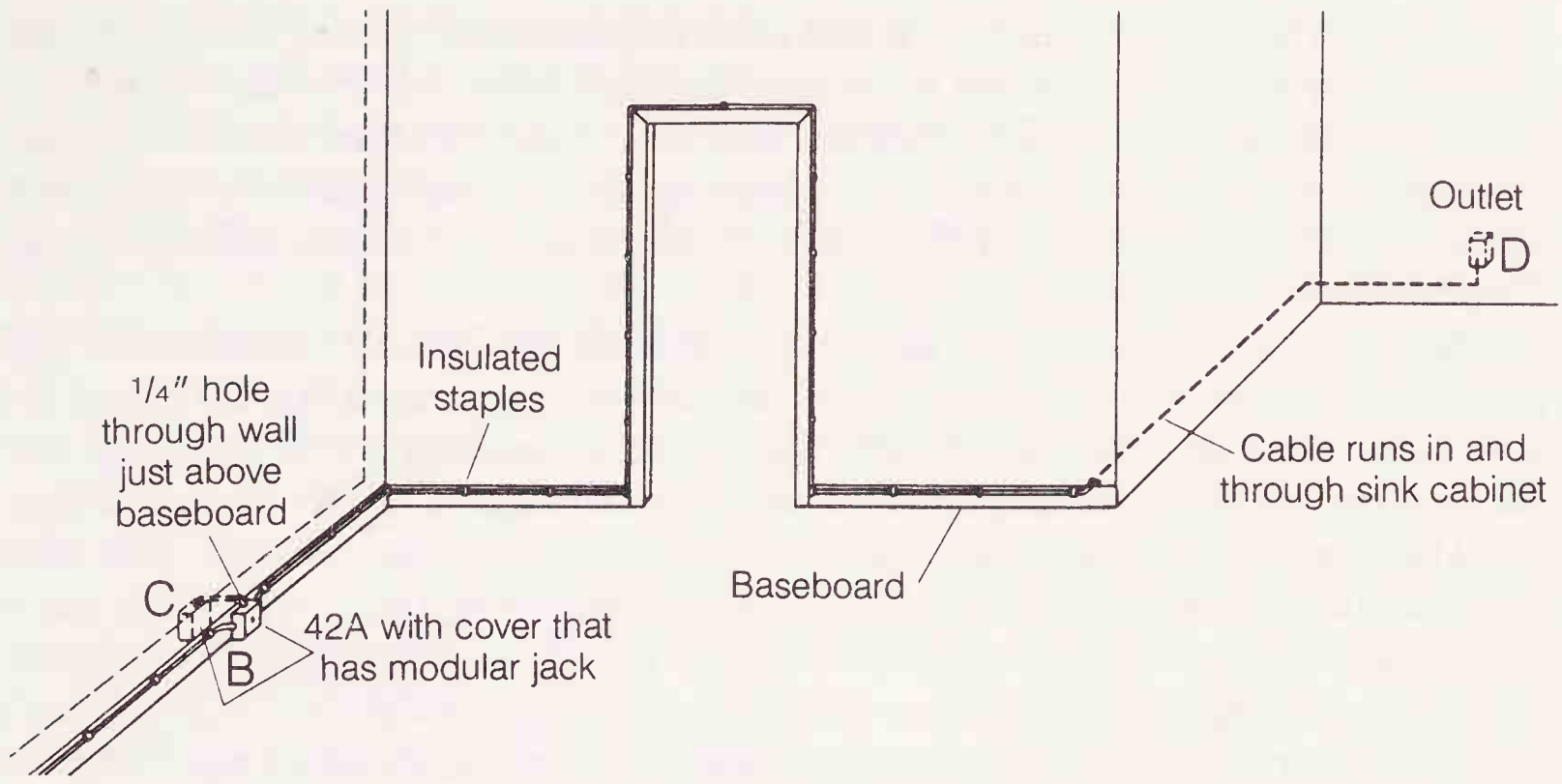


Fig. 3-1. The concept behind telephone wiring and rewiring. (Reprinted from Installing Your Own Telephones, 3rd Edition. *© 1989, Master Publishing, Inc.)*

the cable with a special crimping tool; the tool is available at a number of electronics outlets.

RJ connectors can have two or four contact points inside, and are referenced by a code number. For example, a two-contact connector is an RJ-11, which is suitable for a single-line hookup; RJ-14 connectors have four contacts and are suitable for dual-line hookup.

The four-contact RJ-type connectors are the most common. Obviously, you'll want to match the number of contacts in the connector with the number of conductors in the telephone wire that you use. That is, use an RJ-type connector with four contacts with a phone wire that contains four conductors. TABLE 3-1 summarizes the applications of RJ-type modular phone connections.

Table 3-1. RJ Connector Codes.

RJ Connector	Maximum Lines
RJ-11	1
RJ-14	2

Planning for extension telephone wiring

It often happens: you want to add a fax machine to your home or office, but the telephone outlet just isn't where you want to put the machine. You can always call the telephone company or a private contractor and have them install the outlet, but the cost can be prohibitive—usually about $50 per hour, for job that can last 2 to 3 hours.

Or, if you have the time, patience, and a few assorted tools, you can do the job yourself. You'll save some money and you might even do a better job than the "pros."

Before wiring a new telephone outlet, plan everything on paper. At the very least, measure the distance between where you want to add the outlet and the nearest existing telephone wiring (usually another outlet or the phone junction box, which is located outside your home or office).

Add a few extra feet and be sure to buy at least that much multiconductor telephone wiring (standard lengths are 25, 50, and 100 feet; you can splice the wire if you need longer lengths). Radio Shack sells four-conductor telephone hookup wire in various lengths; the wire is already color-coded to match standard telephone installations.

Also consider junction boxes, splice blocks, and other odds and ends. The exact requirements will vary from installation to installation, so you'll have to play it by ear. A good book on this subject it *Installing Your Own Telephones*, available at Radio Shack.

The basic idea of adding a new telephone outlet is depicted in FIG. 3-2. Merely attach the multiconductor wire to a jack, or splice into the telephone wiring. Be sure to observe the color coding of the wires, as indicated in TABLE 3-2. (NOTE: Some homes

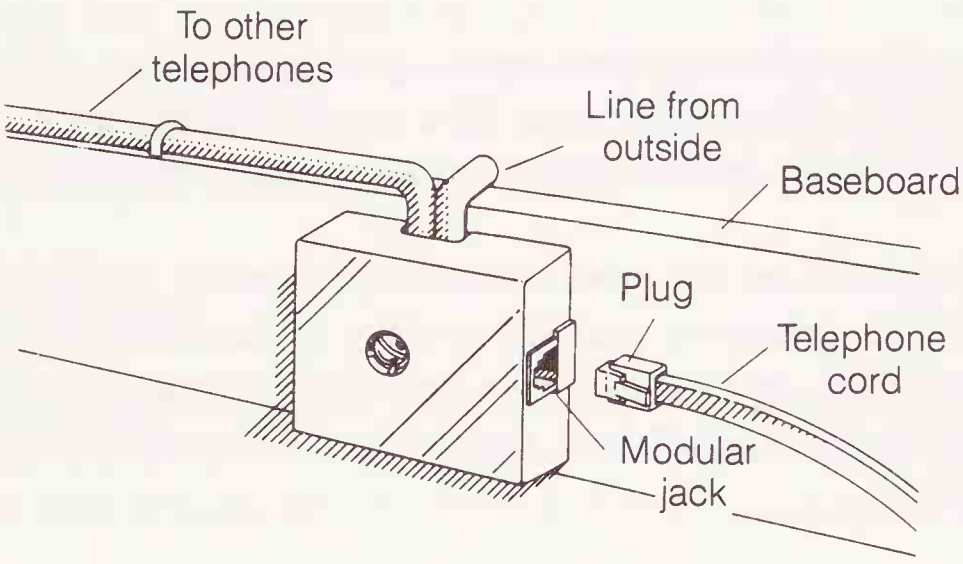


Fig. 3-2. Adding a new modular outlet. The outlet can tap into a nearby line or you can stretch new cable from a distant outlet. (Reprinted from Installing Your Own Telephones, 3rd Edition. *© 1989, Master Publishing, Inc.)*

*Table 3-2. Standard Phone Wire Color Code.**

Line 1 Ring	Red
Line 1 Tip	Green
Line 2 Ring	Yellow
Line 2 Tip	Black
Line 3 Ring	Blue
Line 3 Tip	White

* Typical wiring code designations; some installations may differ

and offices might use different color coding, especially in multiphone systems. If this is the case, you will need to test the function of each wire or call in a service technician.) The red and green wires (easy to remember because they are the colors of Christmas) are the most commonly used.

On the other end of the multiconductor wire, attach a new outlet. This outlet can be installed in a small hole in the wall, along a baseboard, or flush with the wall. Again, observe correct color coding of the wires.

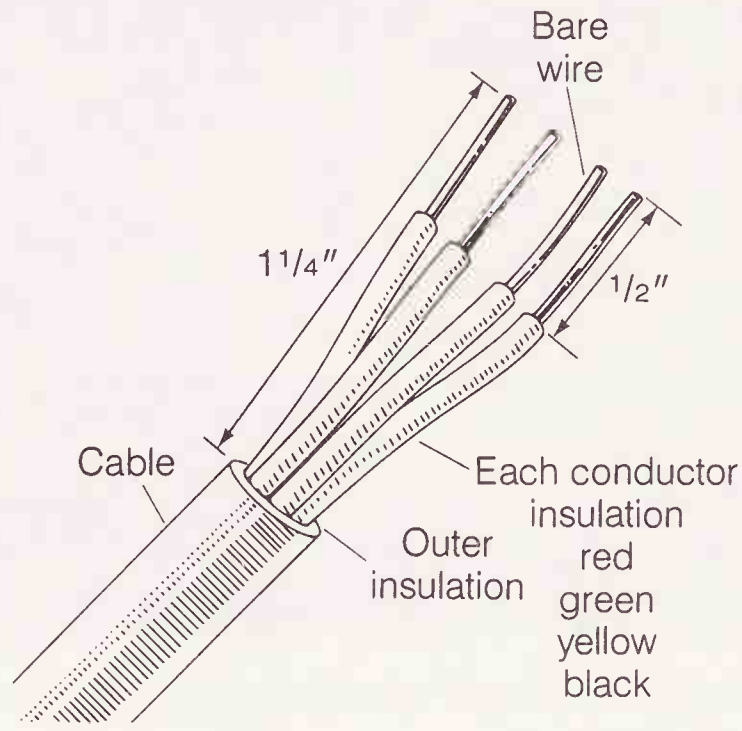


Fig. 3-3. How to correctly strip telephone wire (not too much and not too little). (Reprinted from Installing Your Own Telephones, 3rd Edition. *© 1989, Master Publishing, Inc.)*

Phone installations where you wish the wire to be hidden will require that you fish the wire through the wall, route the wire in the attic or basement, run the wire along the baseboard under the carpet, etc. These installations will provide a much more professional look, but they require special tools and skills. Plus, the changes turn a one-hour job into an afternoon or even weekend job.

Neatness counts

Adding a phone outlet for your fax machines is not a complex job, but sloppy work will lead to potential frustration. Be sure to strip the ends of the wire to approximately one-half inch, as shown in FIG. 3-3. Use a suitable wire stripping tool, not a knife, because the blade can nick the metal conductor of the wire and weaken it.

Outlet boxes use screw terminals for the wire connections. These terminals are ordinary metal screws that are designed so that they cinch down on the wire. Wrap the wire around the shank of the screw and tighten, as shown in FIG. 3-4. *Be absolutely sure* that the wire is secure in the terminal and that adjacent wires don't touch. These two mistakes account for perhaps 90 percent of all telephone-line installation problems.

If you are installing the extension cable along the baseboard, use the proper insulated staples. Don't use uninsulated metal staples, nails, glue, or double-sided tape. Metal fasteners can gouge into the cable and short the connectors inside. Other fasteners, like glue and tape, aren't reliable for a permanent installation.

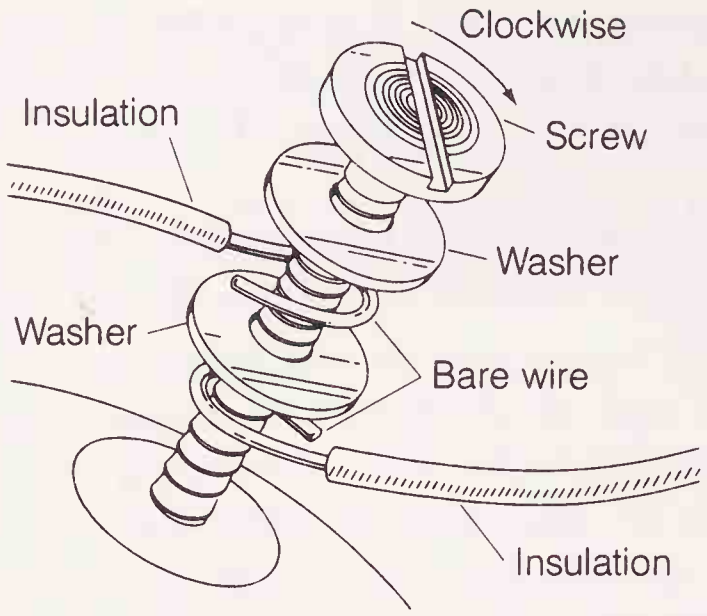


Fig. 3-4. Using screw terminals to hold the wires. Proper electrical contact (without shorts) is a must. (Reprinted from Installing Your Own Telephones, 3rd Edition. *© 1989, Master Publishing, Inc.)*

Fig. 3-5. The proper orientation for fax paper. The imaging side is normally toward the outside of the roll.

Most telephone extension wire is designed for inside use only. The outer insulation is not designed for moisture and direct sunlight. If you must stretch the cord outside the house or office, be sure to use exterior-type extension wire.

Connecting your fax

When the fax machine is out of its box, perched on a table, and positioned by a telephone outlet, everything can be connected together. Use the shortest phone cord length possible. If you have extra, wind a loose loop and tie it with a rubber band. When running the phone cord from the fax to the outlet, don't staple cords or wires to the inside or down the back of a cabinet or wall. You might puncture the insulation.

Whenever possible, keep ac cords separate from phone cords. Otherwise, the phone cords might pick up interference and noise from the ac wires. If signal cables must cross ac cables, run them perpendicular, not parallel, to one another. Avoid placing phone cords under carpeting, because walking over them can deform the insulation, which in turn, can create noise and static in the line.

Testing

When finished, plug the phone cord into the fax and the wall outlet. Install the recording paper in the fax, according to the instructions. Be sure the paper is not installed

upside down; the imaging side of fax paper is the outside of the roll. The sheet should come off the top of the roll (FIG. 3-5).

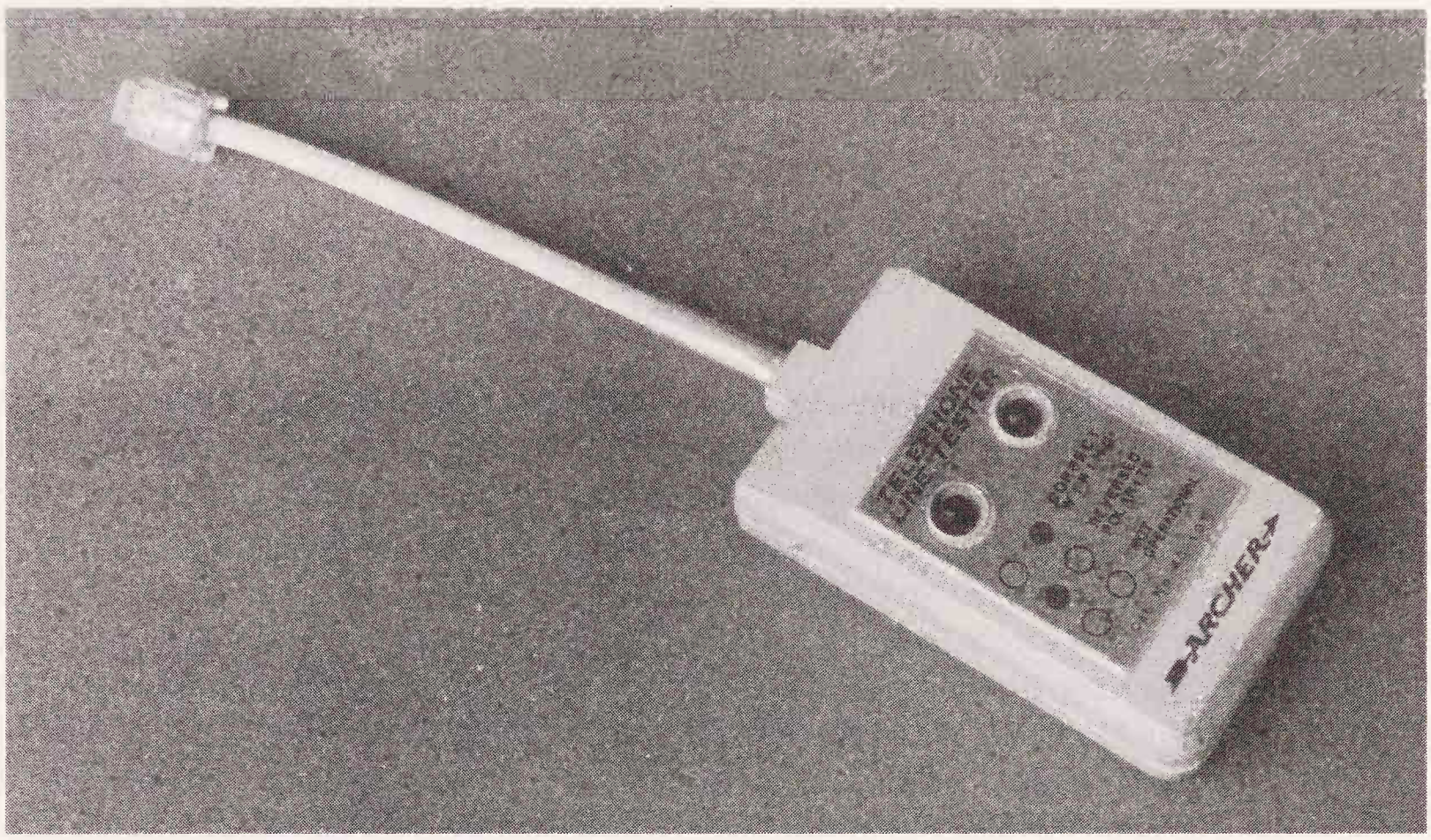


Fig. 3-6. A telephone line tester, which is available for only a few dollars from Radio Shack.

Turn the fax on and test each portion of your system, following the general guide that is provided in the user's manual for your unit. If the instruction manual lacks testing procedures, do the following (the names of some function buttons might be different than on your machine).

1. Look at the indicators on the unit. Is the power light on? If the fax has a liquid-crystal display (LCD) panel, writing should appear—usually a date or prompt of some type. Follow the instructions that are provided in the fax manual for initial machine set-up, if necessary. You might need to set such parameters as the time and date, the number of rings before the fax answers the phone, and other details before the machine will let you send and receive documents.
2. If your fax is equipped with a telephone handset, lift it out of the cradle and listen for a dial tone. If it has no tone, the fax might not be properly connected to the phone line.
3. Replace the handset into the cradle. Find the DIAL button on your fax. Press it, then enter "555-1212." This phone number is a dummy; lift the telephone handset (or an extension phone) and you should hear a recorded message that says your call "cannot be completed as dialed." Press DIAL again, press CANCEL (if your fax is so equipped), or turn the fax off to terminate the call.
4. Write (in pen) or type, on an 8 1/2-by-11-inch sheet of paper. Place this sheet into

the document feeder of the fax. With most machines, the fax will indicate that a document has been loaded (either a beep, an indicator light, or a "document-loaded" message in the LCD readout). Depending on the design of your fax, you will insert the document page face up or face down. Refer to your fax manual for specifics.

5. Press the COPY button on the fax. Assuming the recording paper is loaded correctly and the fax is working as it should, a "local copy" of the document will be made. The original should feed through the fax and the copy should come out concurrently. Examine the copy; it should not contain voids, blotches, or other imperfections.

6. Contact a friend or associate who has a fax machine and arrange a two-part test. In the first part, send a two- or three-page document to the remote fax. After successfully completing this test, have your friend send a two- or three-page document to you.

Once you have initially tested your fax machine and know its basic operation is okay, complete testing by checking all the front panel controls and features. Program a few numbers into the dial memory (if available) and press the speed dial buttons. Do the same for the last memory redial button, the resolution and gray scale buttons, etc. If the fax has additional features, consult the operator's manual and try them. Now is the time to find any hidden problems.

Debugging fax problems

Problems in installation and operation do occur, but finding the fault doesn't have to be difficult. Go one step at a time. If your fax machine doesn't work at all, check to make sure it is plugged in and the power is on. Many fax machines "play dead" until they are properly initialized. This procedure is outlined in the manual that accompanied the machine. Be sure to follow it carefully. Try it a second time if you're not sure the initialization was a success.

If the fax cannot make a call or send a document, suspect the phone line first. Three simple approaches are:

- If the fax is equipped with its own telephone handset, lift it and listen for a dial tone. If you hear a dial tone and you can't discern any noticeable static or noise, you know the fax is at least properly connected to the phone line. If you don't hear the tone, the fax might not be plugged into the telephone line, the line might be wired incorrectly, or the handset itself might not be attached properly. Check all three.

- Temporarily disconnect the fax from the modular phone jack and plug in a telephone that you know works. Listen for a dial tone. If you can hear the dial tone, you know the phone line is operating properly.

- Use a telephone list tester, such as the one shown in FIG. 3-6. This model is available at Radio Shack and it currently is available in two flavors: a single-line tester

and a two-line tester. Cost for both is under $6 each. The line tester indicates if the line is operational and if it has been wired correctly.

A fairly common ailment is a bad phone cord between the outlet and fax machine. If something is amiss, test this cord first. I recall spending over two hours and about $30 in special parts and tools to repair what I thought was bad wiring in a phone extension. No matter what I did, the problem persisted. Only until I tested the phone with a new extension cord did the line work. The moral: always suspect the little things first.

If something goes wrong

Okay. You've connected your fax machine to the phone outlet, did everything that you thought you should do, but it doesn't seem to work.

TABLE 3-3 is a quick troubleshooting guide that you can use to help correct the mistake. These problems assume a simple cause. To diagnose more serious problems, see the troubleshooting flowcharts in chapter 8. Remember that many problems are not caused by the fax, but by the telephone line, the telephone circuits, the paper, the original document, and the overall installation. Always suspect a noncritical related fault first. Chapter 7 details fax machine-related problems and how to solve them.

Achieving optimum document quality

Even if your fax works right out of the box, it's no guarantee that it's working well. The quality of the documents you send and receive is largely determined by special precautions that you make. Unless you're watchful, you can easily turn a good transmission into a bad one, or vice versa. Here are some pointers for making sure that you get the best quality documents possible:

- Use only clean originals. Paper that's smudged by ink, dirt, or copier toner will yield inferior results. In addition, the gunk will lodge inside the fax machine, reduce the quality of subsequent transmissions, and require you to eventually clean the machine. From time to time, you'll want to make a quick test copy (with the COPY button on your fax) to ensure that your machine scans the originals without picking up dirt and other debris.
- Use only "permanent" originals. Ball-point ink drawings, typed pages, or plain-paper copies (with properly operating toner fuser) provide the best results. Avoid transmitting pencil or crayon originals. Avoid sending carbon copies. Test the permanency of the document by rubbing your finger on the writing. If it smears, it could gunk up the fax and produce a low-quality print when transmitted.
- Use only dark originals. The darker the writing, the better the reception on the other end. Pencil yields poor results—sometimes to the point of not reproducing the writing at all!
- Avoid documents with green or greenish-blue writing. The CCD electronic "eyes" used in fax machines are sensitive to most all colors of light. However,

Table 3-3. Basic Troubleshooting Guide, Fax Installation.

PROBLEM	CAUSE	REMEDY
Won't turn on	Not plugged in	Plug into good socket
	Switched outlet	Switch on outlet
	Blown fuse	Replace fuse (usually internal)
Won't place call/answer call	Not connected to phone line	Connect
	Bad phone line/outlet	Inspect and replace, as necessary
	Problem with phone circuits	Wait; call phone company if not resolved
Won't accept document	Paper folded or dog-eared	Smooth paper or photocopy
	Jam in ADF	Clear jam
	Paper too small/too large	Photocopy (reduce/enlarge as necessary)
Original document jams	Paper not inserted properly	Re-insert
	Paper scrap in ADF	Clear object
	Foreign object in ADF	Clear object
	Paper too small/too large	Photocopy (reduce/enlarge as necessary)
Receiver paper jams	Paper not loaded properly	Re-insert
	Paper scrap in ADF	Clear object
	Foreign object in ADF	Clear object
	Incorrect paper size	Correct correct paper
Incomplete transmission/reception	Noisy phone line	Try again
	Bad phone line	Attempt repair; call phone company
	Incorrect conrol panel settings	Reset controls
Blotches, lines, etc. in received doc	Noisy phone line	Try again
	Bad phone line	Attempt repair; call phone company
	Dirty optics in sending fax	Clean
	Dirty printhead in receiving fax	Clean
Fax does not respond to controls	Paper not loaded correctly	Reload paper properly
	Incorrect parameter setup	Reset parameters
	Switches dirty or electrical problem	Turn unit off and on again

the fluorescent lamp used in most fax machines is designed to emit green light; CCDs are most sensitive to this color. This disadvantage of using a colored light over a white light is that documents printed in green or greenish-blue ink might not reproduce well. Green pencil or magic marker might even be "invisible" to the fax machine.

- Use standard-sized paper whenever possible. The minimum paper size for originals on most fax machines is about 3 by 5.5 inches (check the specifications of your model for exact measurements). Smaller paper sizes might cause misfeeds or they might not feed through the machine at all. Be sure the paper size is consistent. Avoid using paper with ragged ("feathered") or textured edges. You can send small or irregularly sized sheets, but you need to insert it into a carrier first. Most fax machines have a document carrier for just this purpose. If yours didn't, you can buy one at most fax and office supply stores. The carrier is nothing more than a transparent plastic pouch.
- Regular 20-pound bond paper is best for originals. Extra thin or thick paper might jam or crumple inside the fax machine. Never attempt to transmit a document printed on onion-skin paper. Avoid heavy stocks, glossy papers, folded paper, whenever possible.
- Smooth paper is best, as long as it's not glossy. Your original documents will feed through the fax machine best if they are a smooth bond, like typing or copier paper. Glossy paper, like from a magazine article or cover, might slip inside the paper transport of the fax and jam the works. *Never* use coated papers, like erasable typing paper, clay-coated paper, or gummed-backed paper (without the protective back sheet). The coating will gum up the inside of the fax.
- Always inspect your originals to make sure that no paper clips, staples, Post-it notes, and other foreign objects are attached to them. All can cause serious problems when fed through the machine.
- Keep your fax away from direct sunlight and sources of heat, like a radiator or a forced-air register. Over time, the heat will affect the receiving paper (the stuff you print on).
- Buy only enough fax receiving paper to last one year. Fax paper has a finite shelf life and its sensitivity diminishes over time. Most offices need only one or two rolls per month. You can often buy fax paper in 6- and 12-roll cartons, but just be sure you'll use them in one year's time (approximately).
- Store fax paper in its original wrapper in a cool, dark place. Keep it away from moisture, heat, and light. A cabinet in the office supplies room should do fine. Select a cabinet away from the sink, radiator, microwave, or any heat-producing appliance.

Fax accessories

Like every office piece, numerous accessories are available for your fax machine. Some are gadgets, but a few are handy add-ons that will increase the versatility of your fax.

Voice/fax switcher

Those who work at home or in a small office might need to share a fax machine with a regular "voice" phone line. A voice/fax switcher is an outboard attachment that connects between your fax machine and the phone line. The switcher automatically directs voice calls to your desk phone (or answering machine) and fax calls to your fax machine. Some switchers add extra intelligence, so they can discern between a human voice, a fax machine, and a computer modem. That way, you can share one phone line three ways. Some of the high-end fax machines have a voice/fax switcher built in.

Stand-alone auto dialers

Stand-alone auto-dialers were all the rage when they first came out because so few desk phones incorporated an auto-dialing feature. Now, even bargain-basement desk phones can memorize at least 10 phone numbers, and the stand-alone auto-dialers collect dust at the phone store. However, you can readily use these same auto-dialers with your fax machine, in case yours doesn't include an automatic dialing feature of its own.

Attach the auto-dialer to the same line as the fax (use a two-way modular coupler, available at Radio Shack). To dial, press a preprogrammed number on the auto-dialer. When the call is established, send your document.

Phone line "accountants"

A phone line "accountant" is an unusual add-on, but it's handy for those who own a fax machine that lacks journal recording capabilities. The telephone account system (available at electronics and telephone stores) records incoming and outgoing calls on a paper tape. You can use the tape to track incoming and outgoing calls. The tape includes the phone number, the duration of the call, as well as an optional four-digit accounting number (you can use this number to reference clients for billing purposes).

Acoustic coupler

If you have a portable fax and a cellular phone, you might want to connect the two together. Few cellular phones include a modular jack to connect external phone add-ons. One alternative is to use an acoustic coupler, essentially two rubber cups that are outfitted with a microphone and speaker. The coupler is attached to the hand set of the cellular phone, then it is plugged into the fax machine.

Fax transmission is not recommended while you're in a moving vehicle (especially if you're the driver). The reason: the phone line might fade or pop as you travel from one transmission cell to another. This can severely affect fax transmission, and in some cases, cause the fax machines to hang up. Dedicated cellular faxes (portable models that are specifically designed for use on cellular lines) incorporate extra circuitry to compensate for momentary signal loss.

4

Tools and supplies for fax maintenance

The tools and supplies that are necessary for proper fax machine maintenance are not extensive or expensive. Apart from common household tools, you need only a few specialty items to maintain your fax in good operating condition and to diagnose minor problems. This chapter details these tools and supplies, and how to use them.

Workspace

Regular fax upkeep does not require the machine to be removed from its comfortable nest in your home or office. As long as you dust the cabinet of the machine regularly and provide adequate ventilation to keep the power supply cool, you need only remove the fax for repair or a preventative maintenance interval.

For minor repair and preventative maintenance, you need a work area that's reasonably free from dust, well lit, and comfortable for you. Avoid taking your fax into a garage or similar work area, where a greater chance exists for dust and airborne oil to contaminate its inner workings. A kitchen table or office desk is ideal.

Before working on the machine, lay out a small piece of clean carpeting or heavy fabric over the work table. This will protect the table, as well as the machine, from scratches and dents. Collect all the tools you'll be using and have them on hand, preferably in a tool box. Special tools and supplies can be stored in an inexpensive fishing tackle box. The tackle box has lots of small compartments for placing the screws and other parts that you remove. If you don't use a box, borrow a cup or bowl from the kitchen to temporarily store the parts that you remove from the fax.

For best results, your workspace should be an area where the fax machine will not be disturbed if you have to leave it for several hours or several days. The work table should also be off limits or inaccessible to young children, or at least the area should be easily supervised. Some of the chemicals used to clean fax machines are highly toxic, so you should keep them out of reach of children.

More importantly, a risk of electric shock exists when the cover of the fax is removed. Take every precaution to avoid injury and never leave the machine unattended, where curious fingers can touch high-voltage wires.

Basic tools

You'll need a screwdriver and a few other common tools to disassemble the machine. Most faxes use Phillips screws to contain the cabinet, chassis, and internal components, so be sure you have a Phillips screwdriver handy. Some machines use flathead or hex screws, but these are the exception, not the rule. Determine which tools you need ahead of time and obtain the proper ones. Don't try to make do with the wrong tool. Using a small flathead screwdriver to loosen an Allen screw only strips the screw head.

If your screwdrivers are not already magnetized, purchase a screwdriver magnetizer at the hardware store. When magnetized, the screwdriver holds on to screws that you remove or reinstall in the fax. The magnetizer lets you magnetize and demagnetize your screwdrivers by scraping the blade across the face of a large speaker magnet.

Be sure to save all the screws you remove; they are not as easily replaced as you think. Most fax machines are made in Japan (a few in Europe), and either use hardware with Japanese or English metric threads or special metal or plastic self-tapping screws. You can't easily find these screws at hardware stores and they can be expensive at specialty outlets.

A pair of pliers is also a handy tool. The pliers can loosen or tighten nuts, grommets, and plastic standoffs. Tweezers or a pair of small long-nosed pliers help you grasp small parts—like screws that have fallen inside the machine! A pair of regular manicuring tweezers is fine, but try to get the kind with the flat, blunt ends. Tweezers with pointed ends aren't as useful.

Volt-ohm meter

A *volt-ohm meter* is used to test voltage levels and the impedance of circuits. This moderately priced electronic tool is the basic requirement for intermediate fax maintenance and repair, and it is necessary for anything beyond routine cleaning. If you don't already own a volt-ohm meter, you should seriously consider buying one. The cost is rather minimal considering the usefulness of the device.

Many volt-ohm meters (or VOMs) are on the market today. For work on facsimile machines, you don't want a cheap model and you don't need an expensive one. A meter of intermediate quality is sufficient and it works admirably. The price for such a meter is between $30 and $75 (usually on the low side of this range). Meters are available at most electronics outlets. Shop around and compare features and prices.

Digital or analog

Two general types of VOMs are available today: digital and analog. The difference is not that one meter is used on digital circuits and the other on analog circuits. Rather, digital meters employ a numeric display, not unlike a digital clock or watch. Analog

VOMs use the older fashioned, but still useful, mechanical movement with a needle that points to a set of graduated scales.

Digital VOMs used to cost much more than the analog variety, but the price difference has evened out recently. Digital VOMs, such as the one shown in FIG. 4-1, are fast becoming the standard; in fact, it's hard to find a decent analog meter anymore.

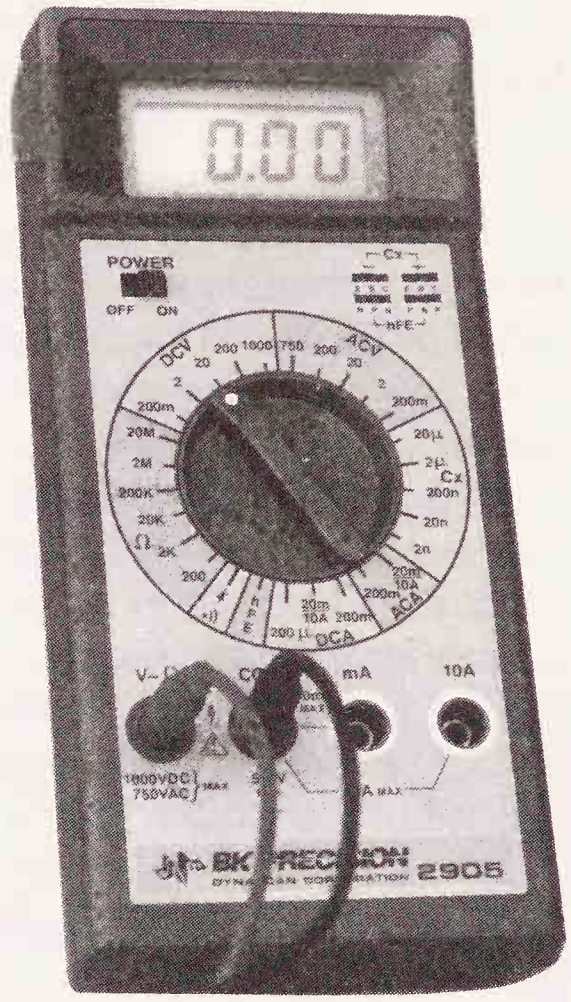


Fig. 4-1. A digital volt-ohm meter.

Analog VOMs are traditionally harder to use because you must select the type and range of voltage you are testing, find the proper scale on the meter face, then estimate the voltage as the needle swings into action. Digital VOMs, on the other hand, display the voltage in clear numerals with a greater precision than most analog meters. Because of their increased popularity and ease of use, this chapter concentrates on digital VOMs.

Automatic ranging

As with analog meters, some digital meters require you to select the range before it can make an accurate measurement. For example, if you are measuring the voltage of a 9-volt transistor battery, set the range to the setting closest to, but above, 9 volts (with most meters it is the 20- or 50-volt range). Auto-ranging meters don't require you to do this, so they are inherently easier to use. When you want to measure voltage, set the meter to volts (either ac or dc) and take the measurement. The meter displays the results in the readout panel.

Accuracy

Little of the work you'll do with fax machines require a meter that's super accurate. A VOM with average accuracy is more than enough. The accuracy of a meter is the mini-

mum amount of error that can occur when making a specific measurement. For example, the meter might be accurate to 2,000 volts, +/– 0.8%. A 0.8% error at the kinds of voltages used in fax machines, typically 6 to 12 volts dc, is only 0.096 volts.

Digital meters have another kind of accuracy. The number of digits in the display determines the maximum resolution of the measurements. Most digital meters have 3 1/2 digits, so it can display a value as small as 0.001 (the half digit as a "1" on the left side of the display). Any lower values are not accurately represented; then again, there's little cause for higher accuracy when working a fax.

Functions

Digital VOMs vary greatly in the number and type of functions they provide. At the very least, all standard VOMs let you measure ac volts, dc volts, milliamps, and ohms. Some also test capacitance and opens or shorts in discrete components, such as diodes and transistors.

For most purposes, these additional functions are not necessary, and you need not spend the extra money on a meter that includes them. To make effective measurements, take diodes and transistors out of the circuit to accurately test them. The design of the latest faxes makes this difficult and inadvisable, even for a seasoned repair technician. Service techs usually repair component failures by swapping the entire circuit board and not replacing individual components.

The maximum range of the meters when measuring volts, milliamps, and resistance also varies. For most applications, including fax troubleshooting, the following maximum ratings are more than adequate:

dc volts	1,000 volts
ac volts	500 volts
dc current	200 milliamps
Resistance	2 megohms

Meter supplies

Most meters have a pair of test leads, one black and one red, each equipped with a needle-like metal probe. The quality of the test leads is usually minimal, so you might want to purchase a better set. The kind with coiled leads is handy. They stretch out several feet, yet recoil to a manageable length when not in use.

Standard leads are fine for most routine testing, but some measurements might require a clip lead. These have a spring-loaded clip on the end; you can clip the lead in place so that your hands are free to do other things. The clips are insulated to prevent short circuits. Also, clips that attach onto regular test leads are available.

Meter safety and use

Most applications of the meter involve testing low voltages and resistance, both of which are relatively harmless to humans. Sometimes, however, you might need to test high voltages—like the input to a power supply. Careless use of the meter can cause

serious bodily harm. Even when you're not actively testing a high-voltage circuit, it might be exposed when you remove the cover of the fax.

If the machine is plugged in while the cover is off (which it will be if you're testing for proper operation) and you're not measuring voltages at the power supply, cover the power-supply terminals, if exposed, with a piece of cardboard or insulating plastic.

For proper meter use, set the meter beside the unit under test, making sure it is close enough for the leads to reach the test points inside the machine. Plug in the leads and test the meter operation by first selecting the resistance function setting (use the smallest scale if the meter is not auto-ranging). Touch the leads together: the meter should read 0 ohms.

If the meter does not respond, check the leads and internal battery and try again. If the display does not read 0 ohms, doublecheck the range and function settings, then adjust the meter to read 0 ohms (not all digital meters have a 0 adjust, but most analog meters do).

Once the meter has checked out, select the desired function and range, and apply the leads to the fax circuits. Usually, the black lead will be connected to ground, and the red lead will be connected to the various test points in the fax machine. Figure 4-2 shows a test of the fax power supply.

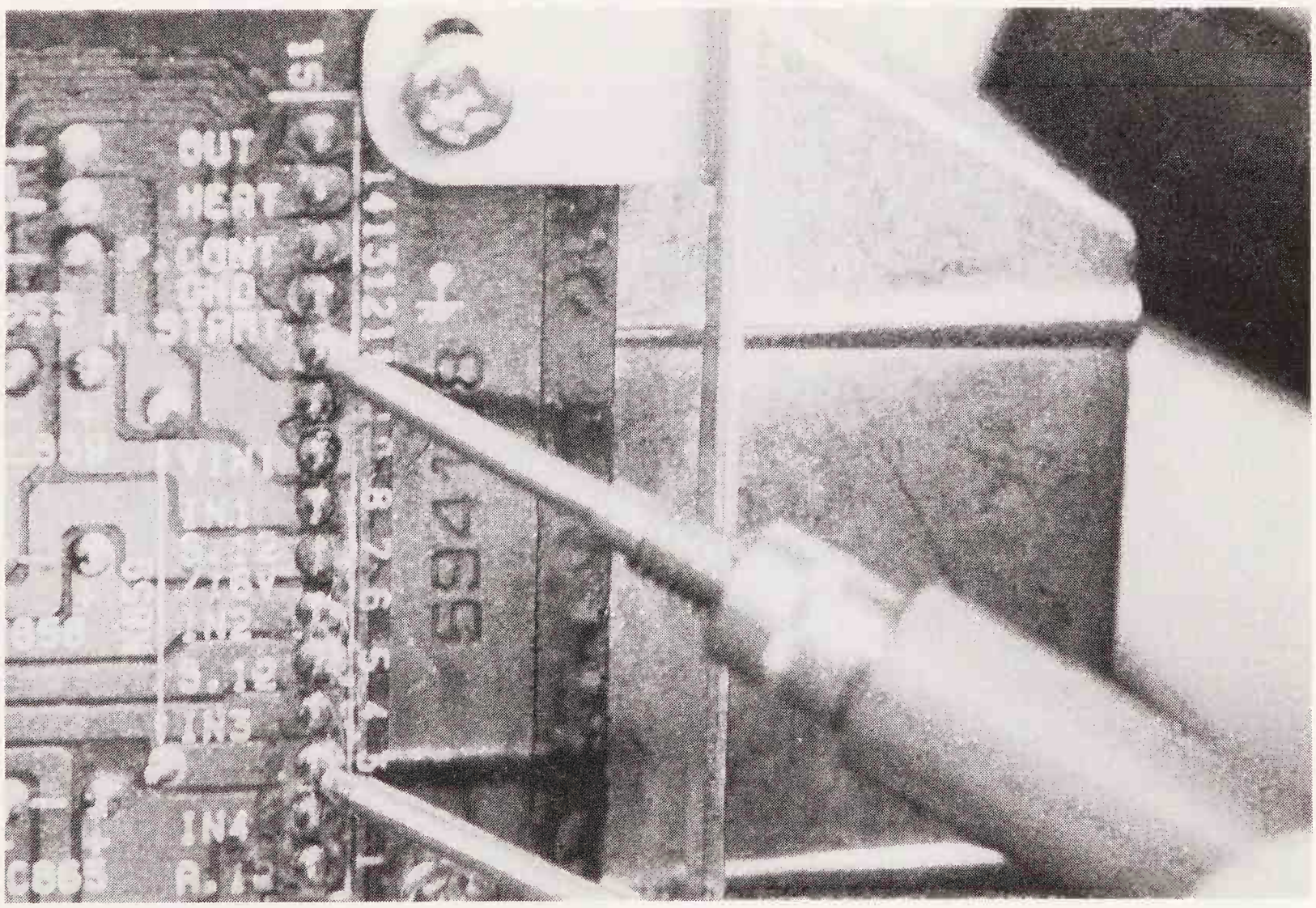


Fig. 4-2. An example of using a volt-ohm meter.

Never blindly poke around the inside of a fax in an attempt to get some kind of reading. Apply the test leads only to those portions of the machine that you are familiar with: switch contacts, power contacts, and so forth. If you have a schematic diagram for the fax machine, refer to it for the location of the test points.

One safe way to use the meter is to attach a clip on the ground lead and connect the clip to the chassis or circuit ground. Use one hand to apply the red lead to the various test points; stick the other hand safely in your pocket. With one hand "out of commission," you are less likely to receive a shock as a result of carelessness.

Logic probes

Meters are typically used to measure analog signals. Logic probes test for the presence or absence of low-voltage dc signals, which represent digital data. The 0's and 1's are usually electrically defined as 0 and 5 volts, respectively (although the actual voltages of the 0 and 1 bits depend entirely on the circuit). You can use a meter to test a logic circuit, but the results aren't always predictable. Further, many logic circuits change states quickly (pulse) and meters cannot track the voltage switches fast enough.

Logic probes, such as the model in FIG. 4-3, are designed to give a visual and (sometimes) aural signal of the logic state of a particular circuit line. One LED on the probe lights if the logic is 0 (low) and another LED lights if the logic is 1 (high). Most probes have a built-in buzzer, which has a different tone for the two logic levels. With the buzzer, you don't need to keep glancing at the probe to know the logic level.

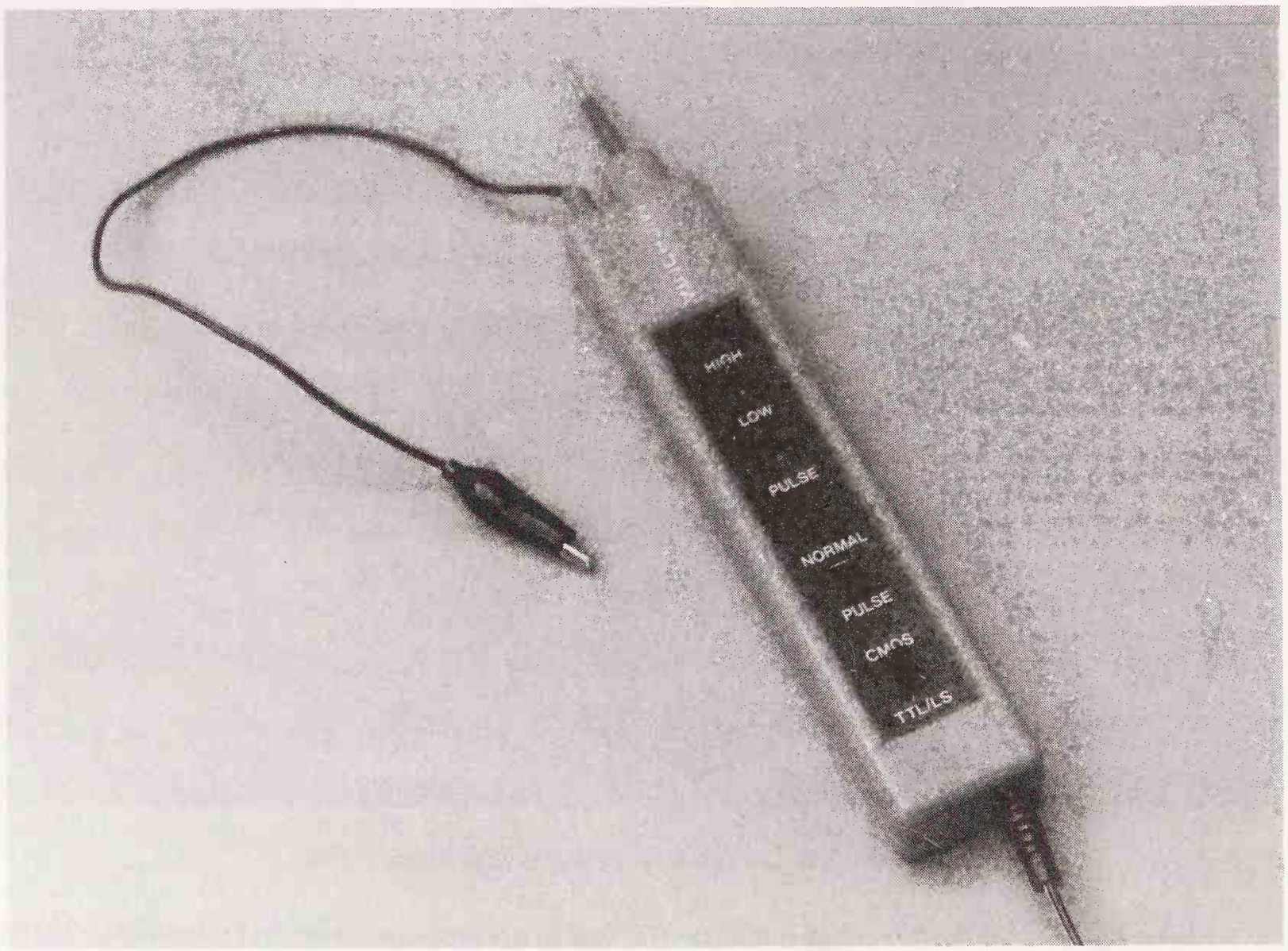


Fig. 4-3. A logic probe.

A third LED or tone can indicate a pulsing signal. A good logic probe can detect that a circuit line is pulsing at speeds of up to 10 MHz, which is more than fast enough for fax applications. The minimum detectable pulse width (the time the pulse remains at one level) is 50 nanoseconds, again more than sufficient for testing facsimile machines.

Although logic probes might sound complex, they are really simple devices and their costs reflect this. You can buy a reasonably good logic probe for under $20. Most probes are not battery operated; instead, they obtain operating voltage from the circuit under test.

Unless you plan an in-depth troubleshooting and repairing binge, a logic probe is not as important as a VOM. It is a handy tool to have should the need ever arise, but it is not necessary for routine maintenance.

Using a logic probe

The same safety precautions that apply to meters apply to logic probes. When the cover of the machine is removed, potentially dangerous high voltages might be exposed. If you are working close to these voltages, cover them to prevent accidental shock. Logic probes cannot operate with voltage exceeding about 15 volts dc, so if you are unsure of the voltage level of a particular circuit, first test it with a meter to be sure it is safe.

Successful use of the logic probe really requires you to have the circuit schematic for reference. It's nearly impossible to blindly use the logic probe on a circuit without knowing what you are testing. A single fax machine circuit board might contain components for both digital and analog signal processing, and you must know exactly what each component does and how it is used. Since the probe operates from the circuit under test, you need to know where to pick off suitable power. You can easily damage the probe—and possibly the circuit under test—if you connect the power leads incorrectly.

To use the probe, connect the probe's power leads to a voltage source on the board. Clip the black ground wire to circuit ground and touch the tip of the probe against a pin of an IC or the lead of some other component. Figure 4-4 shows a probe testing the logic level at an IC pin.

Please note: Fax machines often use negative voltages, with respect to ground. To the logic probe, little difference exists between connecting the power leads to a positive and ground rail or connecting the power leads to a negative and ground rail. However, avoid connecting the power leads to positive *and* negative rails, because the voltage differential might exceed the maximum supply voltage of the probe. For instance, connecting the lead between the +9 and −9 rails will feed 18 volts to the probe, which is higher than its rated operating voltage.

Logic pulser

The *logic pulser* is a handy troubleshooting accessory when working with digital circuits. This device emits a timed pulse, which lets you see the effect of the pulse on a

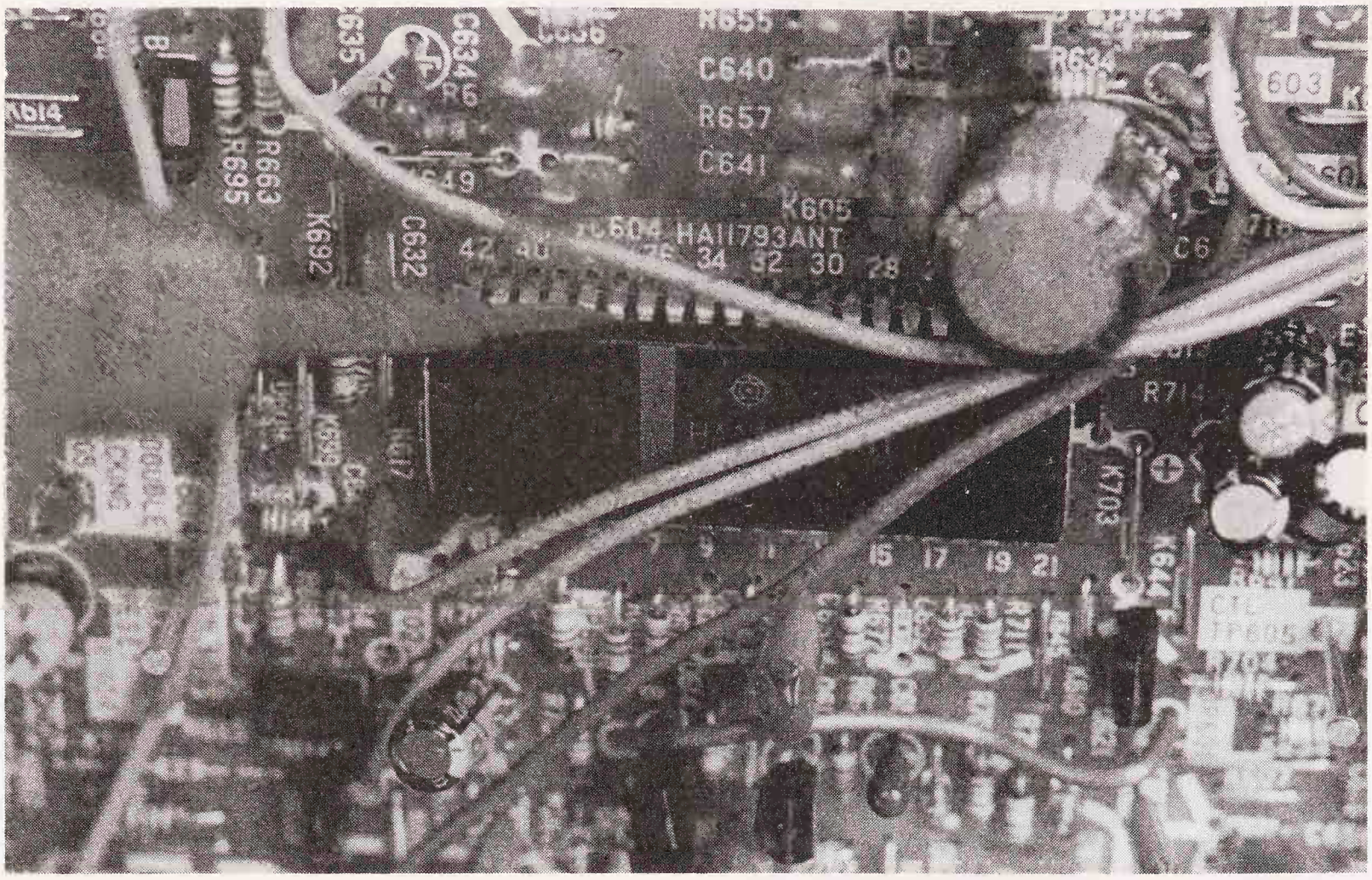


Fig. 4-4. Example of using a logic probe.

digital circuit. Normally, you'd use the pulser with a logic probe or an oscilloscope. The pulser is switchable between one pulse and continuous pulsing.

Most pulsers obtain their power from the circuit under test. It's important that you remember this. With digital circuits, it's generally a bad idea to present a device with an input signal that's greater than the supply voltage for that device. In other words, if a chip is powered by five volts, and you give it a 12-volt pulse, you'll probably ruin the chip. Some circuits work with split (+, −, and ground) power supplies, so be sure to connect the leads of the pulser to the correct power points.

Also be sure that you do not pulse a line that has an output, but no input. Some integrated circuits are sensitive to unloaded pulses at their output stages, and an improperly applied pulse can destroy the chip.

Making your own pulser

You can make your own pulser from a 555 timer IC, available (cost: under $1) from most any electronics outlet store. A suitable schematic is shown in FIG. 4-5. The pulser can be constructed on a small piece of perforated board or universal circuit board. Power for the pulser should be derived from the circuit under test (see following information) or it can be powered by a battery that delivers less dc voltage than the circuit you are testing. The 555 chip operates over a wide range of voltages, from about 3 to 15 volts, which makes it suitable for interfacing with a variety of digital circuits. A finished pulser is shown in FIG. 4-6. The total cost for all parts for the pulser is under $5.

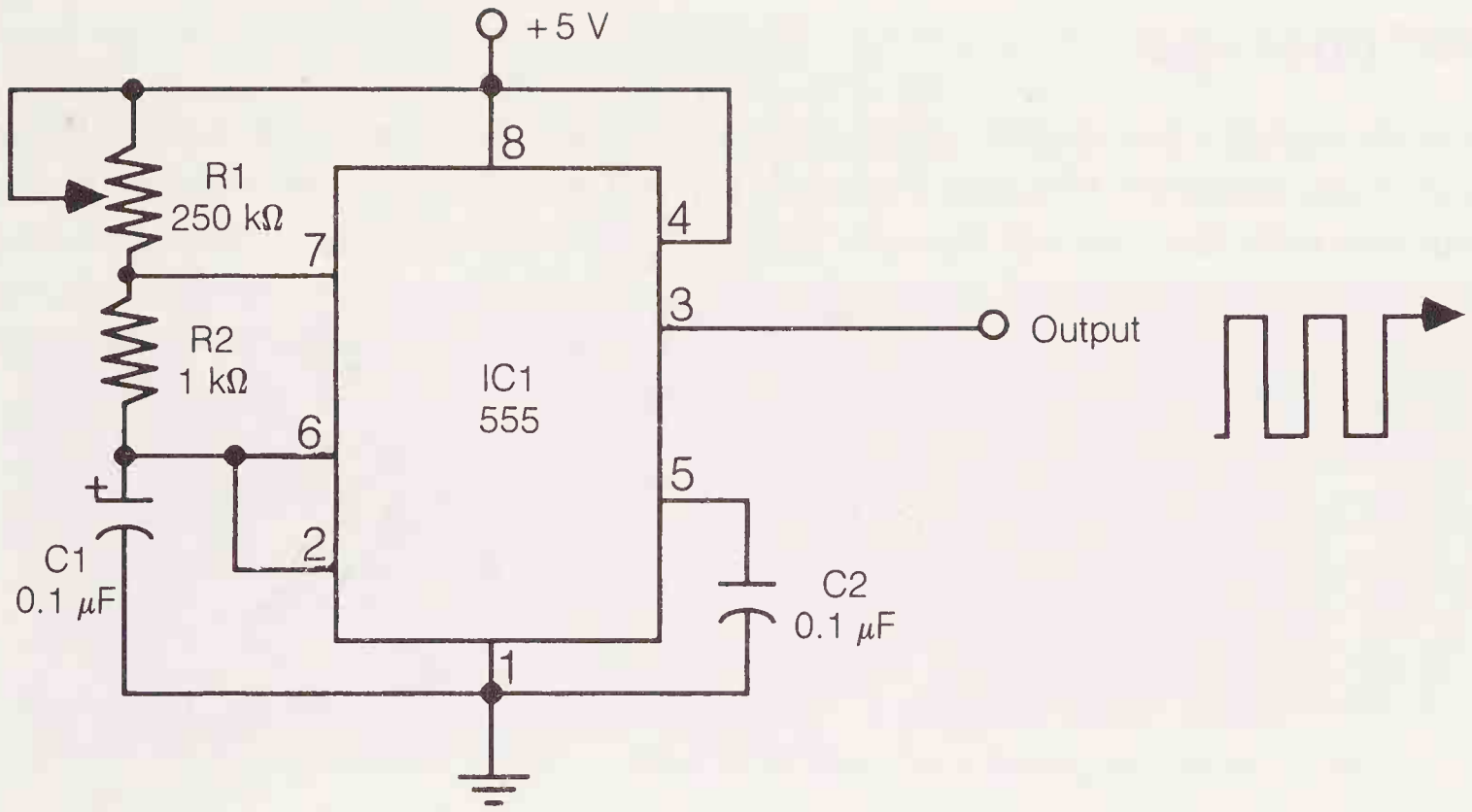


Fig. 4-5. Use this schematic diagram to build an electrical "pulser" for testing purposes. The circuit uses a commonly available 555 integrated circuit, available at most electronics stores for less than $1.

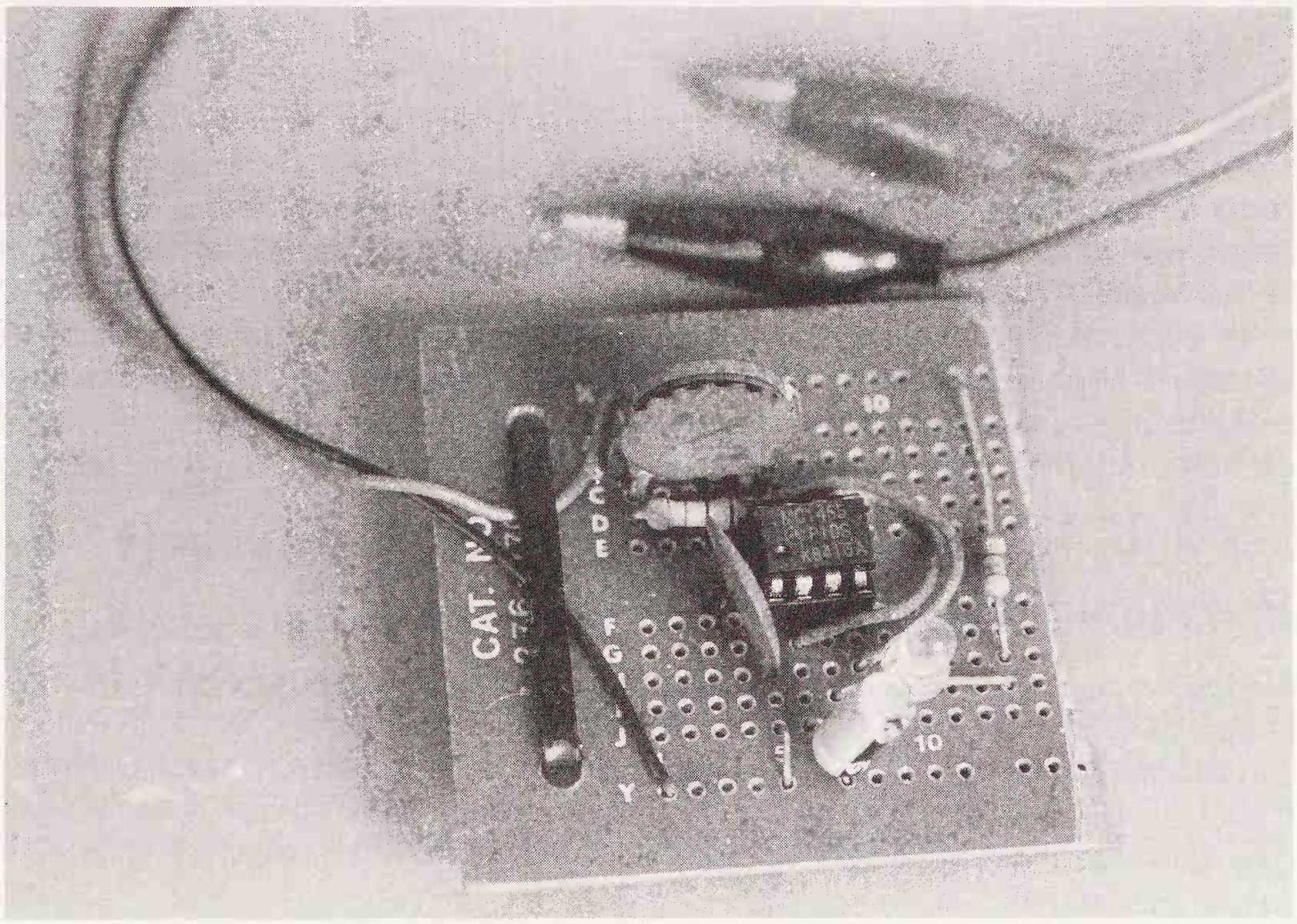


Fig. 4-6. How the "555 pulser" looks when components are soldered onto a piece of universal solderboard. All components seen here are available at most electronics stores.

Oscilloscope

An *oscilloscope* is a pricey tool—good ones start at about $500, and only a small number of electronic hobbyists own one. For really serious work, however, an oscilloscope is an invaluable tool—one that will save you hours of time and frustration. Things you can do with a scope include some of the things you can do with other test equipment, but oscilloscopes do it all in one box and generally with greater precision. Among the many applications of an oscilloscope, you can:

- Test dc or ac voltage levels.
- Analyze the waveforms of digital and analog circuits.
- Determine the operating frequency of digital, analog, and RF circuits.
- Test logic levels.
- Visually check the timing of a circuit to see if things are happening in the correct order and at the prescribed time intervals.

The troubleshooting and maintenance procedures that are covered in this book do not require the use of an oscilloscope, but you'll probably want one if you want to delve deeper into fax machine repair. Many service manuals and schematics for faxes indicate the proper waveform (the visual appearance of the electrical signal on the oscilloscope screen) at specific test points.

A basic, no-nonsense model is enough, but don't settle for the cheap, single-trace units. A dual-trace (two channel) scope with a 20-to-25-MHz maximum input frequency should do the job nicely. The two channels let you monitor two lines at once, so you can easily compare the input signal and output signal at the same time. You do not need a scope with storage or delayed sweep, but if your model has these features, you're sure to find a use for them sooner or later.

Scopes are not particularly easy to use; they have lots of dials and controls that set operation. Thoroughly familiarize yourself with the operation of your oscilloscope before using it. Knowing how to set the time-per-division knob is as important as knowing how to turn the scope on. As usual, exercise caution when using the scope with or near high voltages.

Frequency meter

A *frequency meter* (*frequency counter*) tests the operating frequency of a circuit. Like the oscilloscope, it is not an absolute requirement for intermediate-level fax maintenance and troubleshooting. Most models, such as the one shown in FIG. 4-7, can be used on digital, analog, and RF circuits for a variety of testing chores. You need only a basic frequency meter, a $100 to $200 investment. You can save some money by building a frequency meter kit.

Frequency meters have an upward operating limit, but it's generally well within the region that is applicable to fax machine applications. A frequency meter with a maximum range of up to 50 MHz is enough. Higher-priced meter might have a *prescaler*—a device that extends the useful operating frequency to 500 MHz and above.

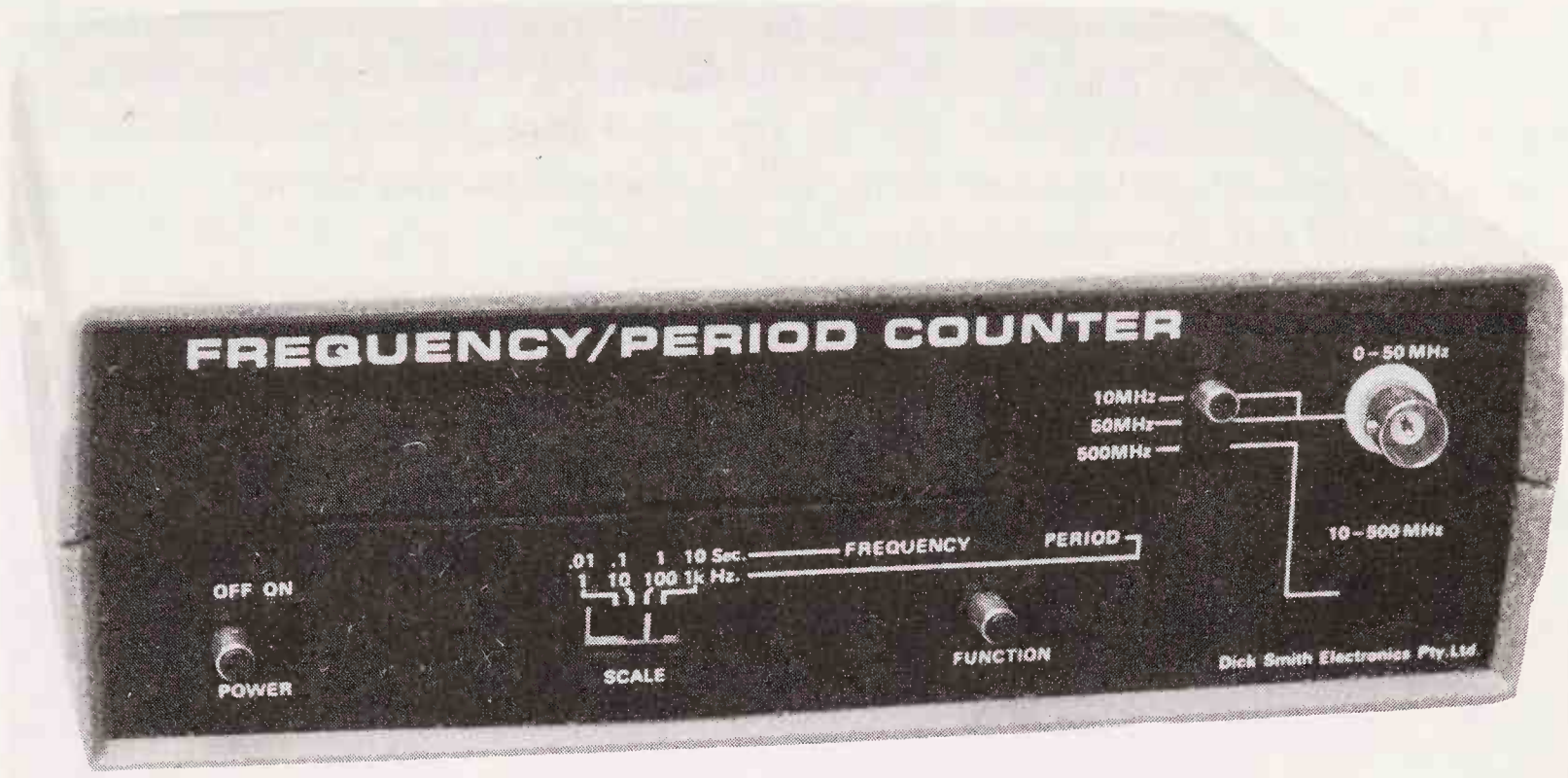


Fig. 4-7. A frequency meter.

Assorted supplies

Unlike the family automobile, the office and home fax requires little (if any) oiling and lubing. Some cleaning and lubrication supplies might be necessary, however, and any well-equipped maintenance kit will have a little of both.

Spray cleaner

The exterior cabinet of the machine can be cleaned with a damp sponge. If dirt and grime are a problem, use a mild spray household cleaner. Apply the spray to the sponge or cloth, but not directly onto the cabinet. Excess can run inside and possibly cause damage.

Cleaner/degreaser

Freon, the stuff used as a coolant in air conditioners, is also a solvent. Unlike most petroleum-based solvents, Freon doesn't melt plastics, and the kind of Freon that you can readily buy is nontoxic and nonflammable. It does have a distinctive odor, but it is harmless (although not to the environment).

Freon by itself can be used as a basic degreaser and cleaner. You can use it to remove things like grime and dirt in hard to reach places. Freon is available at most any industrial supply house. If such a business is not nearby, purchase a can of compressed air at a photographic store. Hold the can upside-down to expel the pure Freon propellant.

Freon is often mixed with alcohol to make a more potent cleaner. Use caution with this stuff: it is flammable and toxic. The Freon and alcohol mixture can be used as a general cleaner, a degreaser, even as a video head cleaner. Chapter 5 shows you how to use the mixture to clean components inside the fax machine.

The Freon/alcohol mixture is available as an all-purpose cleaner/degreaser that you can buy in a spray can. The cleaner is available at most any electronics supplies store. Figure 4-8 shows a couple of cans that use Freon and alcohol in various mixtures, but they all pretty much do the same thing. These cleaners leave no residue, so you can spray it on and it'll dry with no trace.

Fig. 4-8. An assortment of aerosol cleaners.

The cleaner/degreaser can be used on all the internal fax components, including the printed circuit board, thermal head, and reader bar, but *not* rubber parts, such as the rollers. Always remember to turn the machine off and let it cool before spraying. Otherwise, you run the risk of a short circuit. *Never* spray cleaner on a warm or hot printhead; you could ruin it instantly. In short, do not use a spray cleaner on these components if the fax has been recently operated.

Although Freon is an easy to get and inexpensive industrial cleaner, its major drawback is that it is a chlorinated fluorocarbon (CFC). Scientists and environmentalists have pinpointed CFCs as the main culprit for ozone depletion in our atmosphere. The ozone layer, which is many miles above the earth, is primarily responsible for preventing damaging ultraviolet rays from reaching the earth's surface.

Because of the destruction that CFCs cause to the environment, they are slowly being phased out. However, as of this writing, alternative cleaners to Freon and other

CFCs are hard to find. If you can locate a CFC-free cleaner, then by all means use it. Otherwise, continue to use the Freon-based cleaner, but only when needed. Don't waste it.

Grease and oil

Though fax machines have numerous mechanical components, most do not need any special lubrication. The reason: The parts are either inpregnated with a lubricant (usually a high-viscosity oil) or are made with a material, like Teflon (eek, another CFC!), which does not require lubrication. Some lubrication might be called for, however, especially if the machine has been used in adverse environments (a portable fax would fall into this category) or if it is more than two or three years old.

Just about any light machine oil can be used for the components that need lubricated. The oil should not have anti-rust ingredients. Good candidates are 3-in-1 oil or most any oil designed for sewing machines. Another good oil is that kind that is designed for musical instruments. The high-grade oil is available in a handy applicator bottle. Some bottles have a blunt syringe-type needle for applying the oil in hard-to-reach places.

The best oil to use is that which is designed for small machined parts. This oil, which is packed in a small bottle with a blunt syringe applicator, has special penetrating lubricants that ordinary oils lack. You can buy this oil at most industrial supply houses and at some camera and electronics stores, but it is fairly expensive—about $3 for a very small tube.

If the oil you have doesn't have a convenient syringe-type applicator, buy a set of disposal hypodermic needles at the drug store. The needles are usually available behind the counter and they can be purchased by adults without a doctor's prescription. Cost is under 50 cents per hypodermic.

To suck the oil into the hypodermic, open the can or jar of oil and dip the needle in it. Pull the plunger back slowly; the oil will sluggishly seep into the hypodermic. To use the syringe, point the end of the needle directly on the spot you want to oil, then push gently on the handle. Apply only a small amount of oil. Exercise care when handling the syringes and always keep the protective caps in place when not in use.

The "grease" should be a high-quality industrial lubricant, such as Lubriplate, or a non-petroleum-based silicone product. A variety of lubricants are available. A light-grade lubricant, such as that used in 35mm cameras, is suitable. You can obtain it from most industrial supply stores and camera repair shops. A small tube goes a long way.

Refer to chapter 5 for more details on common fax components that require oiling and lubrication. Some mechanical components do not require oil or lubrication, and in fact can be harmed by them. Motors and all rubber parts fall into this category. It's a safe bet that if no sign of oil or lubricant exists on a mechanical part, it does not need it!

Miscellaneous cleaning supplies

A variety of other supplies might be handy when repairing and maintaining a fax machine.

- Brushes let you dust out dirt. Any good quality painter's or artist's brush will do. Stock a small and wide brush so you can tackle all jobs.
- Photographic bulb brushes combine the wisping action of a soft brush with the cleaning action of a strong puff of air. Get the bulb brush at most any photo shop.
- Contact cleaner enables you to clean the electrical contacts in the machine. The cleaner is available in a spray can, but you can apply it by spraying the cleaner onto a brush, then whisking the brush against the contacts.
- Cotton swabs help you soak up excess oil, lubricants, and cleaners. They are available in quantity at any drug store.
- Sponge-tipped swabs are like cotton swabs, but they leave no little pieces of lint behind, and they are ideal for use when cleaning the reader bar and printhead. The swabs can be purchased at most electronics stores and at the cosmetic counter at the drug store.
- Bandage gauze is clean (sterile in fact) and lint-free. Get the softest, largest sheet you can find.
- Small chunks of untreated, virgin chamois or deerskin are a suitable alternative to sponge-tipped swabs. Purchase the chamois at an auto parts store and cut a portion of it into small 1-inch squares.
- Orange sticks (from a manicure set) and nail files let you scrape junk from circuit boards and electrical contacts.
- The eraser on a pencil can rub electrical contacts clean—especially ones that have been contaminated by the acid from a leaking battery.
- Modeling putty (for plastic models) can be used to mend cracks and chips on the plastic exterior of a fax cabinet.
- Contact cement, white glue, and other common adhesives are excellent for repairing broken plastic and metal parts.
- A small magnet makes it easier to pick up screws and ferrous metallic objects that have been accidentally dropped into the machine.
- A fluid called "Regrip" helps rejuvenate rubber parts that are used in rollers, platens, wheels, and belts. Alcohol and Freon-based products should not be used to clean rubber parts, because it can dry them out. Don't use any product (such as "Non-Slip," available at Radio Shack) that leaves a tacky residue.
- Platen cleaner is used on typewriters and computer printers to clean the soft rubber printing platen. Platen cleaner can also be used inside fax machines to clean and rejuvenate the rollers and other rubber parts. Unlike straight alcohol, platen cleaner doesn't dry out rubber.

5

General cleaning and preventative maintenance

"An ounce of prevention is worth a pound of cure." The saying applies in many walks of life and it definitely is true for facsimile machines. A few well-spent moments keeping your fax in top-notch condition goes a long way to keep it healthy. You'll save money in the long run and enjoy your fax investment more. A clean fax is a happy fax.

In this chapter, you'll learn how to give your fax machine a routine preventative maintenance checkup. You'll also learn how to test the machine for proper operation and how to diagnose frequent jamming problems.

Frequency of checkup

The preventative maintenance (PM) interval for your fax machine varies, depending on many factors. Under normal use, you'll want to give the machine a PM checkup every 6 to 12 months. Normal use is when a fax is operated in an average office environment, not a factory floor or at a machinist's convention.

You might need to perform the PM checkup on a more timely basis if your fax is subjected to environmental extremes or is exposed to heavy doses of dust, dirt, water spray (especially salt water), airborne oil, and sand. A chart of suggested PM intervals for machines that receive light, medium, and heavy use appears at the end of this chapter (FIG. 5-19).

How do you know if your fax needs a preventative maintenance checkup? Good question. Experience is your only guide, but if you have not yet gained the experience in how often the machine needs routine maintenance, you can't judge if the service interval is required. As you become acquainted with your fax machine, you will know when it needs a checkup. In the meantime, here are some clues that can point you in the right direction:

- The outside of the fax is covered with caked-on dirt, dust, or other grime. If the outside is dirty, so is the inside.

- The summer has come and gone and you feel your portable fax has seen all the good times with you. Was your fax tossed into the back seat for a beach party? Even if it still runs, it's no guarantee that it's having an easy job at it.
- The pages it receives just aren't what they used to be. Something is amiss inside the fax, but not seriously enough to entirely impair operation.
- The machine makes unusual sounds during sending and receiving.

For the preventative maintenance schedule of your fax machine, as a general rule, clean your fax every 4 to 8 weeks if it is used for less than 25 pages each day.

If you only use your fax machine for a couple of pages a day—whether you are sending or receiving documents—you can probably get by with general cleaning every three or four months. Avoid putting off preventative maintenance any longer than two months, even if the machine is seldom used, because dust can settle and interfere with the proper functioning of the mechanism.

On fax machines that see heavy use (50 pages or more each day) perform the routine cleaning and preventative maintenance every two weeks.

Clean the fax more often if you are plagued with frequent paper jams or if the prints are smudged because of paper dust and other contaminants. You'll also want to clean the machine immediately if the pages you send or receive are too light, uneven, partially blank, or even completely blank.

A word of caution

Unless you are an authorized repair technician for the brand of fax you own, taking it apart to perform the preventative maintenance procedures outlined in this chapter will probably *void the warranty*. Most fax machines have a warranty period of one year or so (some more, some less), and you might as well take advantage of it. Usually no reason exists to perform a PM checkup within the warranty period.

One exception to this rule is if the machine has been accidentally damaged by water, dirt, or sand. Although it still works, you'd feel better if it was cleaned. Factory warranty service does not cover this type of cleaning and you'd pay handsomely for it. The cleaning and "repair" cost might well exceed the price you paid for the machine. In this case, nothing should stop you from doing the work yourself. If your fax is subjected to heavy abuse, check the first aid procedures in chapter 6.

Personal safety

Once again, I must remind you that potential dangers lurk inside your fax. If your model is ac-operated, removing the cover exposes 110 (or more) volts of alternating current. Given the right circumstances, this current can kill you. Remember to unplug the unit at all times when you are not actually testing its operation. Unless otherwise specified, make all maintenance and repair procedures with the fax machine off and unplugged from the wall socket. It is important to unplug the unit. Even with the power

switch off, electricity is still present at the terminals near the unit's power supply, unless the machine is unplugged.

Warning signs that appear on the back of ac-operated faxes and in their manuals, say that potentially dangerous voltages are inside. When you see the triangle and lightning bolt sign, as shown in FIG. 5-1, exercise caution. The other warning sign, the triangle and exclamation point, also shown in the figure, means that you should refer to the owner's manual before operating the equipment. Although few people actually do this, it's still a good idea.

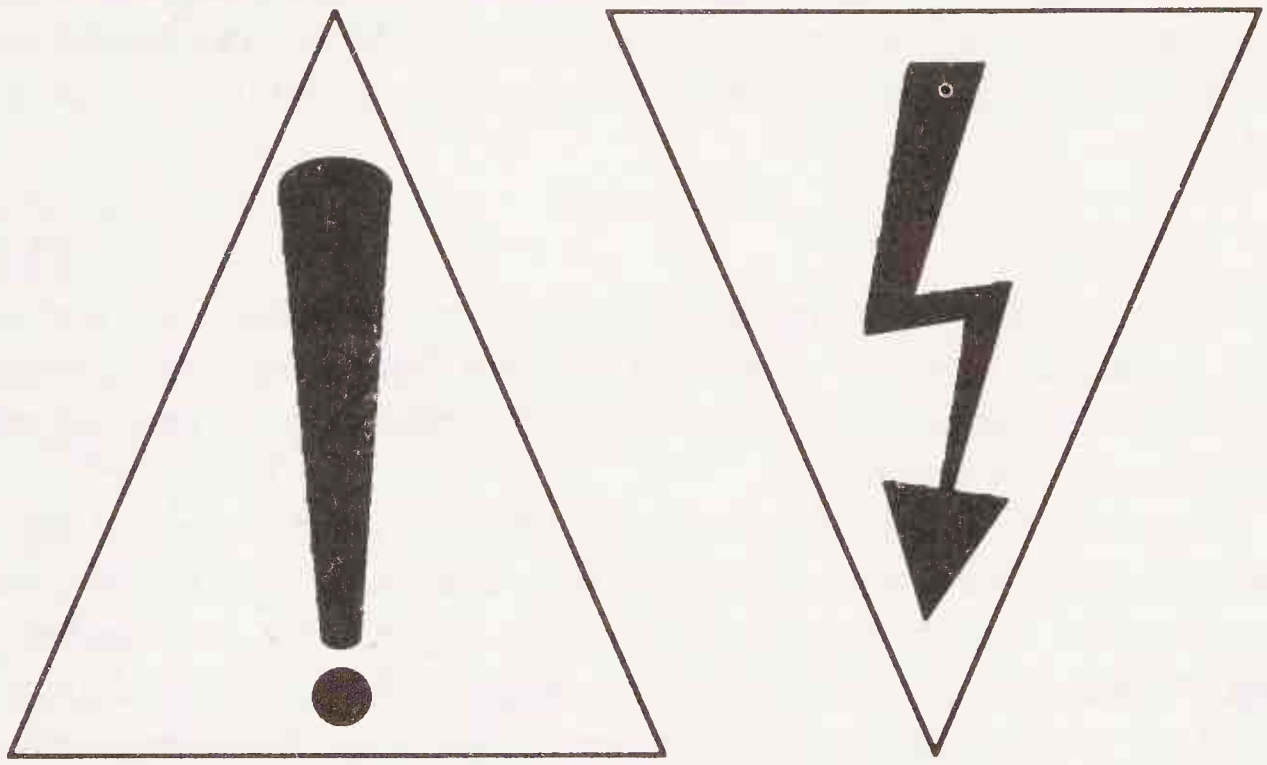


Fig. 5-1. Heed these warning signs whenever you see them. They are designed to protect you.

WARNING: Do not perform the steps in this chapter unless you feel confident in your ability and have observed all safety precautions. Take your time and think about every step. If you don't feel you have time for the general cleaning and maintenance procedures, put it off until another day when you have more opportunity. Rushing things will surely lead to disaster.

General maintenance

Before you poke inside the fax machine, first take a close look outside. You can perform these preventative maintenance steps on a more regular basis because they do not require you to remove the cover of the machine.

Manuals of operation

An important measure in your efforts to minimize fax troubles is to read the instruction manuals for your equipment. This might sound obvious, but you'd be surprised how many fax users never bother to thoroughly read the operating manuals. The manufacturers of the equipment include the manuals so you can get the most out of your expensive purchase. Keep them at hand and refer to them whenever you have a question.

Exterior dust and dirt

On the top of your system maintenance list should be routine external cleaning. Every few days, wipe each component of your fax machine with a dry cloth. Don't use dusting sprays; these actually attract dust and lure dirt back onto your equipment. Use a soft, sable painter's brush for those hard-to-reach places. Be sure to clean the ventilation slots, because they are favorite hiding places for dust.

If you need to get rid of stubborn grime, apply a light spray of regular household cleaner onto a clean rag, then wipe with the rag. Never apply the spray directly onto the machine, because the excess can run inside. Never apply a petroleum- or acetone-based solvent cleaner because it might remove paint and melt the exterior plastic parts. Some plastics, when in contact with a solvent, emit highly toxic fumes that could seriously injure you.

Cords

The cords and connectors in your facsimile system can make your fax sneeze and wheeze too, so be sure that they're on tight and that none of them are damaged. Many fax owners have a tangle of cords tucked behind the machine; just one bad wire or connector in the bunch can cause grief.

First of importance is the telephone cord, which is used to connect the fax to the phone line that leads from your home or office. Telephone cord is composed of four strands of thin wire, bonded together in a plastic sleeve. This cord cannot cope with torture, yet it's often subjected to twisting, tugging, kinking, and tight looping.

If you've got excess, wind it loosely; never bundle it up like extra speaker wire. Be certain that none of the telephone cord is in foot traffic. Don't route it under carpets because walking over the cord can deform the insulation, create shorts, and other problems. A trip on the cord can tug on the connectors, or worse yet, yank your equipment onto the floor.

While inspecting the cord, remove any kinks. Look closely at the connectors that are attached to the ends of the cord to make sure they are on tight and are not broken or bent (see FIG. 5-2).

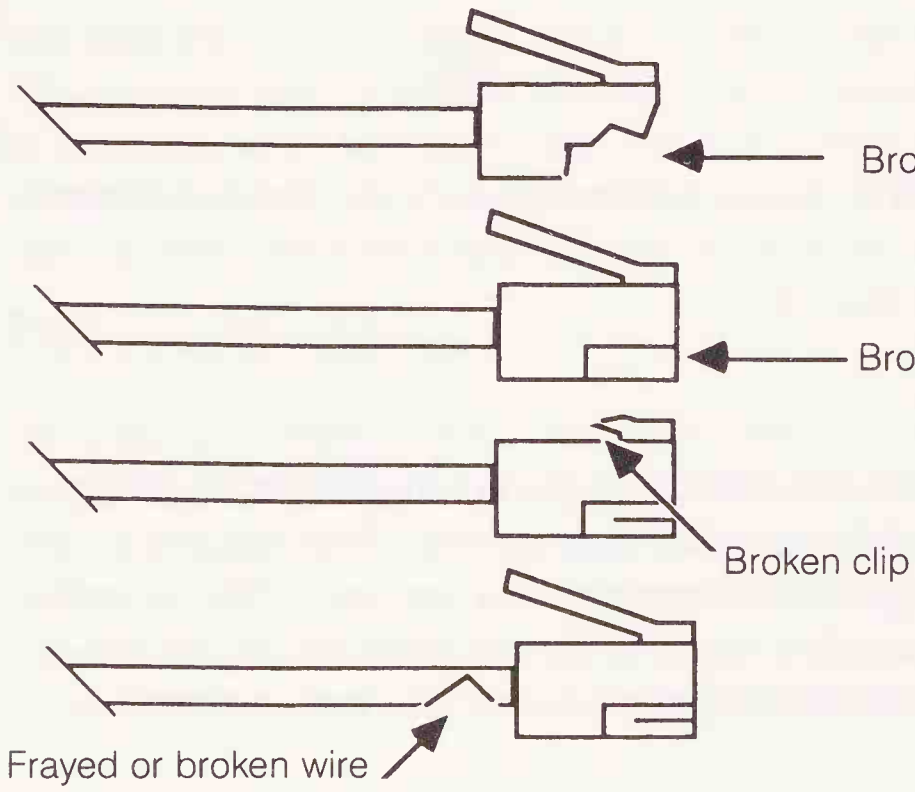
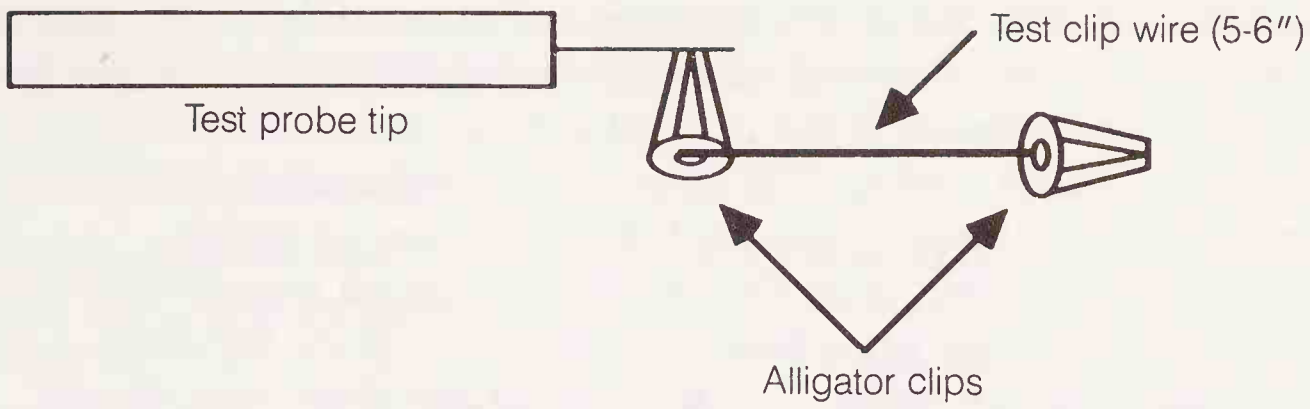
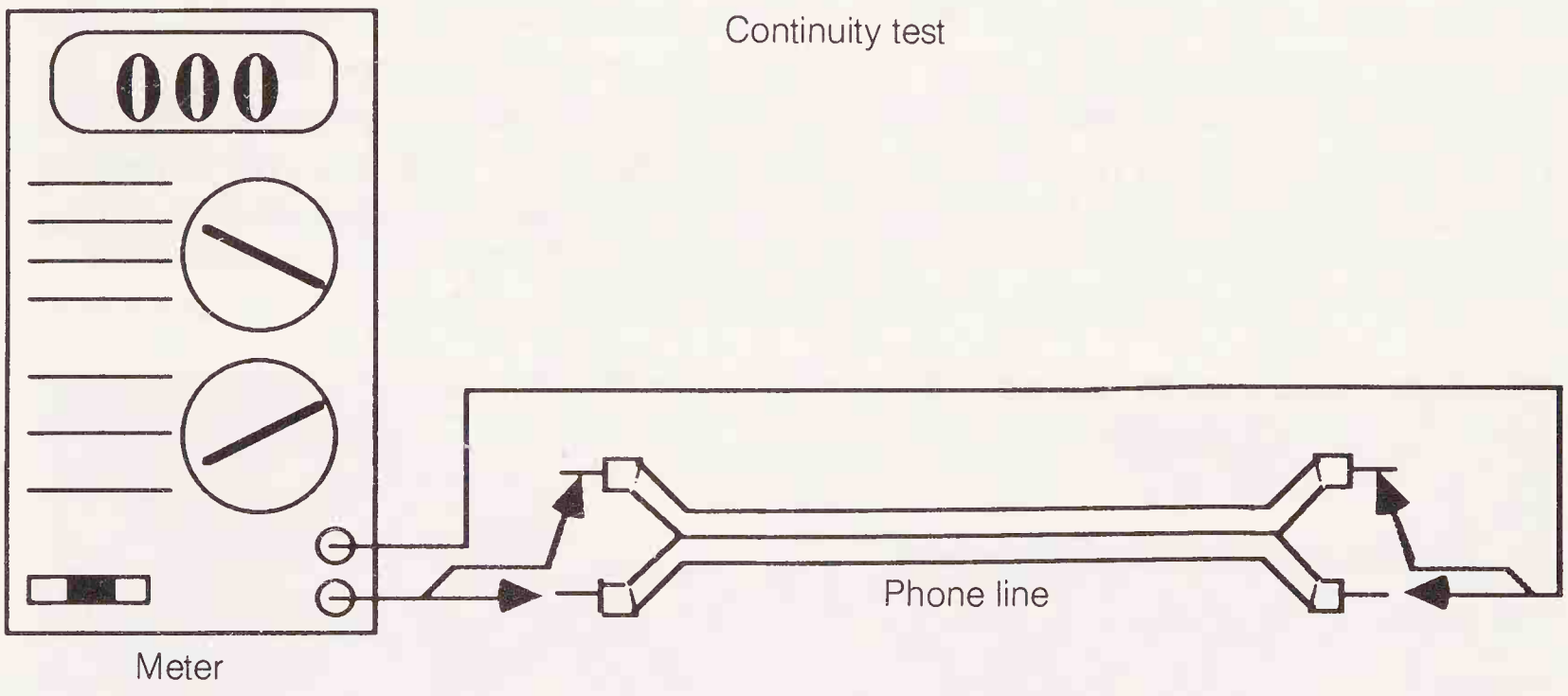


Fig. 5-2. Be sure that all phone cords and connectors are in good shape. Common problems are shown here.



Continuity test



Short test

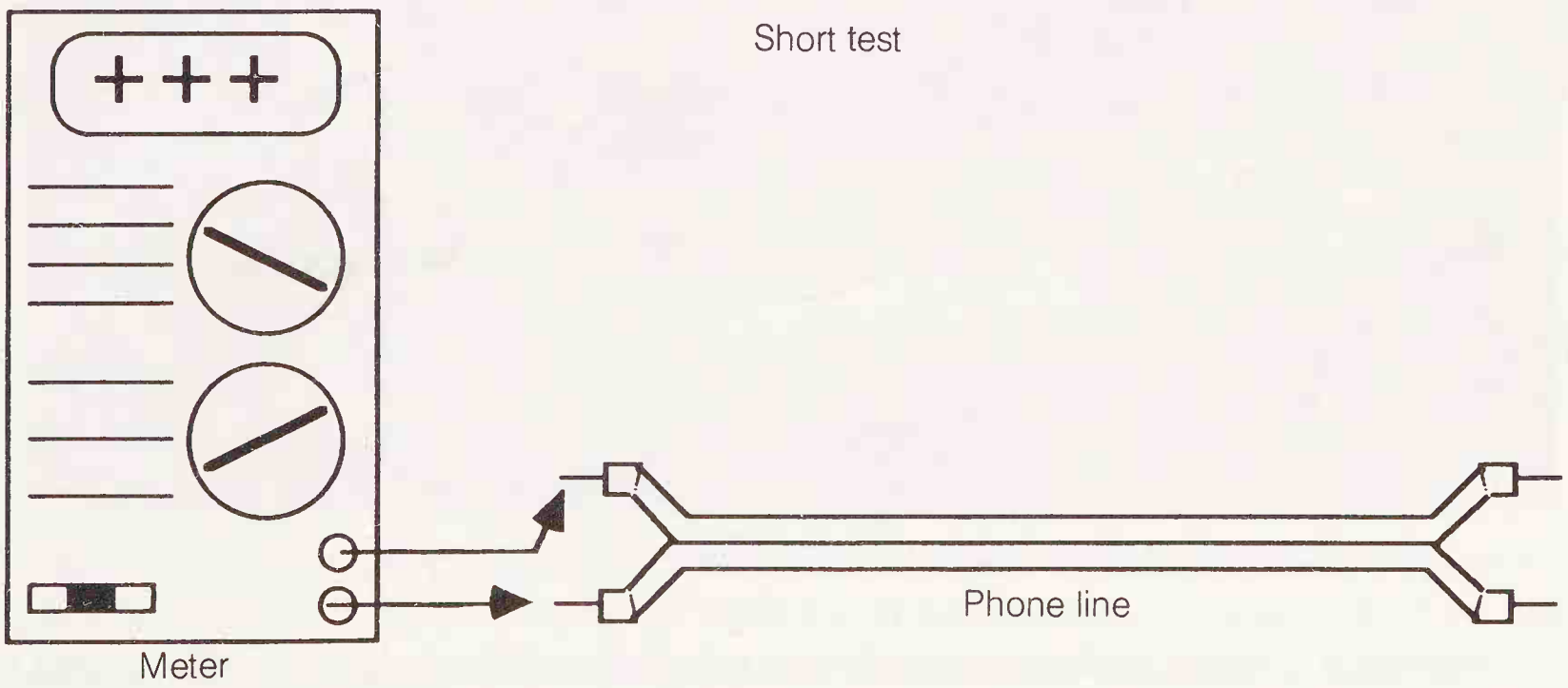


Fig. 5-3. How to make a test jig with two alligator clips and a short length of wire (you can buy such "jumper cords" already made at Radio Shack). Use the jumper cord to test for opens and shorts in wires.

If you suspect that a cord is bad or causing telephone line problems, try a replacement. Alternatively, you can use a volt-ohm meter and a homemade telephone cord testing jig (FIG. 5-3) to test the continuity of the cord. Attach the leads of the meter to the test points on the jig and take a reading. The meter should read 0 ohms. Do the same for the three remaining wires (some telephone cords contain two six wires).

Also, as shown in the illustration, apply the test leads to adjacent wires in the cord to check if the cord is shorted (be sure not to hold the metal probes of the test leads or you might get false readings). The measurement should read infinite ohms (open circuit).

Internal preventative maintenance

You can often gain sufficient access to the insides of a fax machine simply by opening the clam-shell cabinet, as shown in FIG. 5-4. There, you can access the optics, reader bar, paper platen, printhead, paper compartment, and other components. Most fax machines also let you access the fluorescent light (to illuminate the page when sending a document) by way of a removable panel. This panel is often located on the bottom or at the back of the machine. If you remove this plate, the additional internal components are exposed.

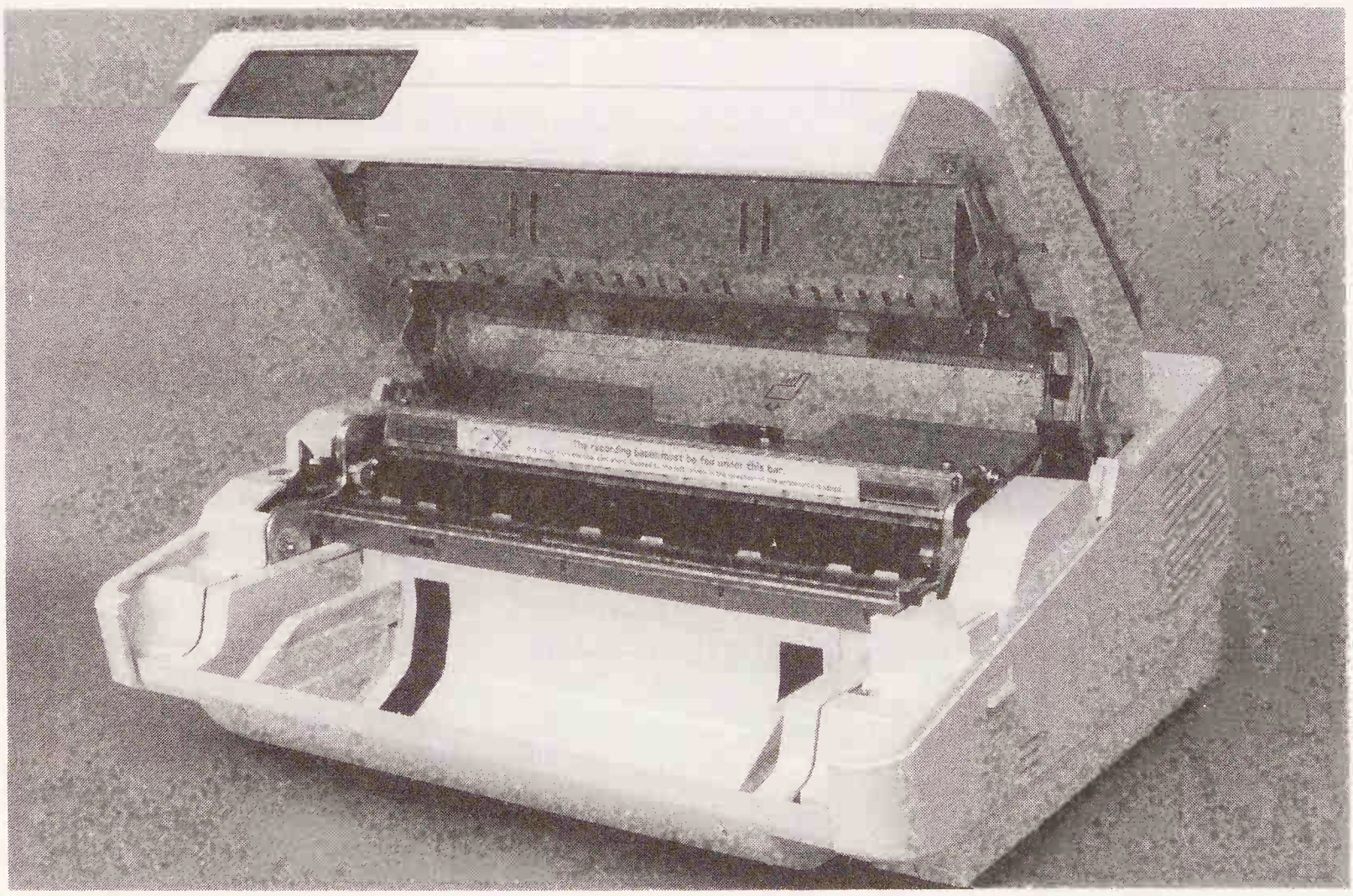


Fig. 5-4. A fax machine with its clam shell open.

For most preventative maintenance tasks, this extent of disassembly is required. Additional disassembly is not needed, nor is it advisable.

However, some heavy-duty maintenance and repair procedures require that you get deeper inside the fax machine. To gain access inside, remove the fax machine from its

location in your home or office. Disassemble the fax only in an open, well-illuminated work area, as described in more detail in chapter 4.

Remove attachments

Before disassembling the fax machine, remove all attachments, like telephone handsets, automatic document feeders, and paper trays. In most models, these just lift or snap out. Look for small screws that hold the attachments in place; never simply yank them off! Open the fax machine and remove the roll of paper inside.

Be sure not to skip this step. Removing the attachments makes complete disassembly of the unit much easier, and it prevents the small metal and plastic parts from breaking.

Disassembly

Diassembling most fax machines is straightforward, but you should be sure to proceed with caution. The typical ac-operated unit is composed of a top and bottom piece; loosen two or more screws and remove the top portion of the cabinet. The screws are usually located at the rear and sometimes at the side of the machine, as shown in FIG. 5-5. Detach the bottom panel by removing the screws on the bottom (see FIG. 5-6).

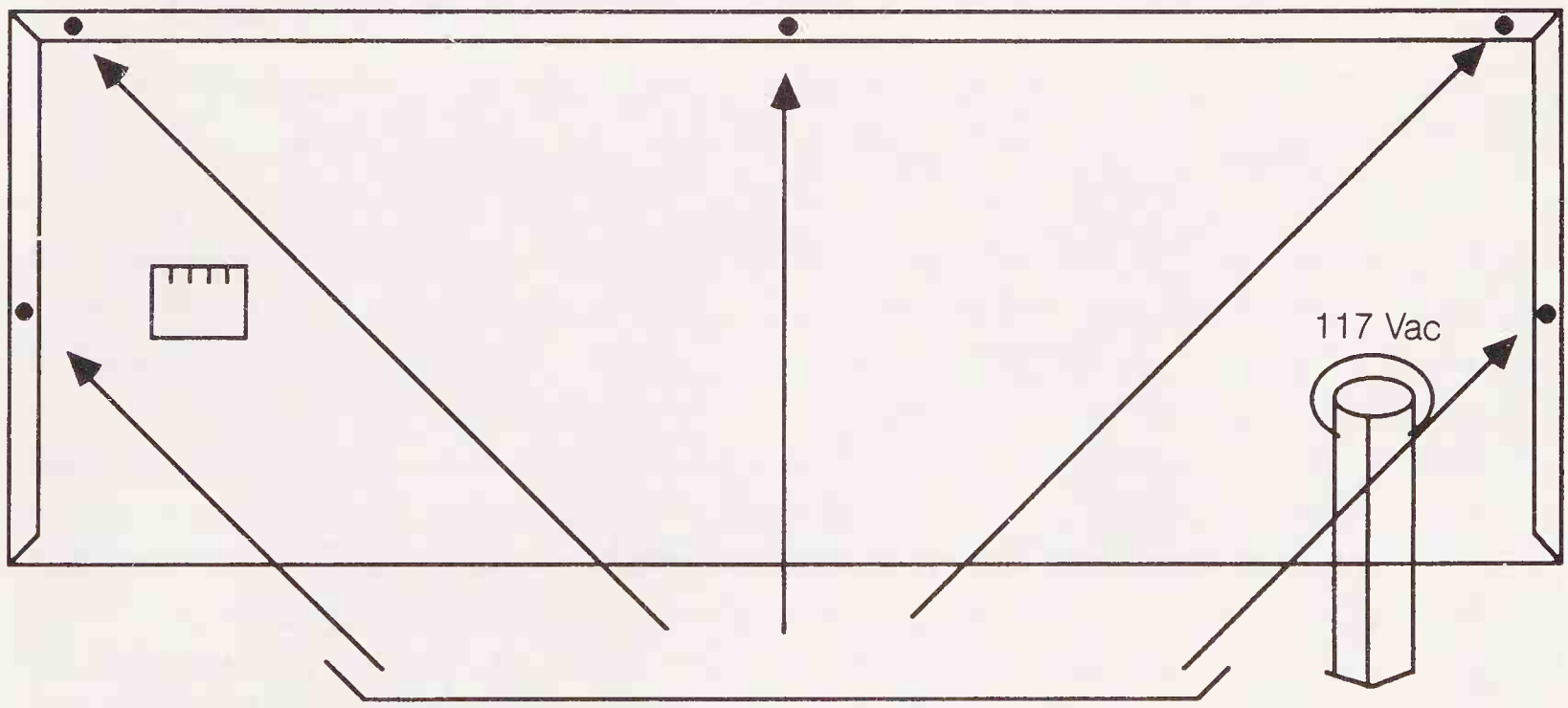


Fig. 5-5. Typical screw locations for the top/back cover of the fax machine (of course, your machine might differ).

Don't loosen every screw you see—especially those on the bottom center portion of the cabinet—because they might anchor some internal components. Loosen one screw at a time and attempt to remove the cover (or at least see if it is loosening). Run your fingers along the edges of the cabinet to see where it is still catching. If a screw seems to hold an internal component in place, retighten it and try another.

The cabinet screws in some fax machines are marked with an arrow or light speck of paint to indicate that they should be removed. If the screws on your fax are so identified,

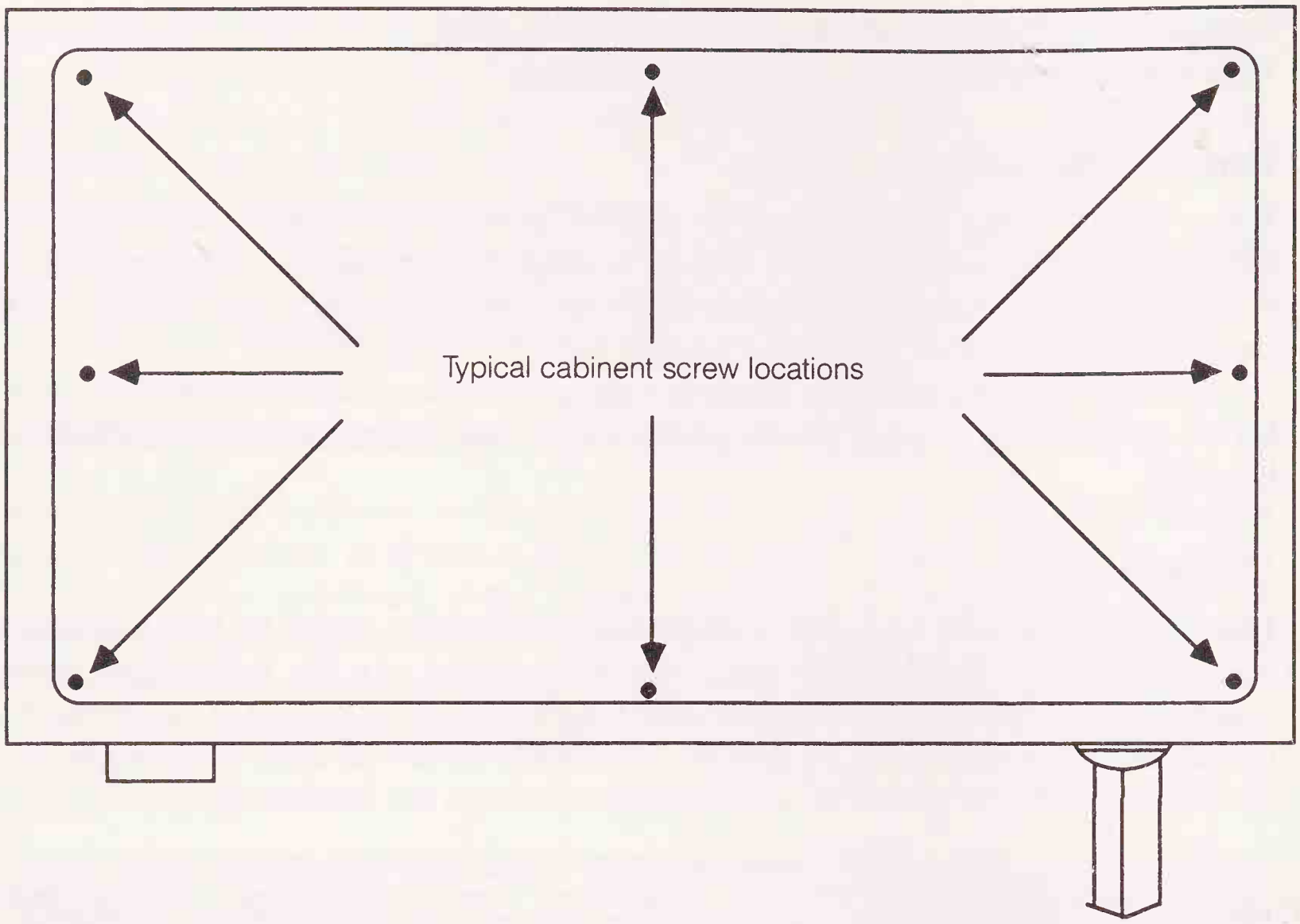


Fig. 5-6. Typical screw locations for the bottom cover of the fax machine (your machine might differ).

remove only the ones that are marked. Leave the others. Many fax machines require that you open the clam-shell before disassembly. If the fluorescent light in your fax machine is accessible through a panel in the back or bottom of the machine, that too, might need to be removed to access the cabinet screws.

Save the screws in a cup or container. If the screws are different sizes (they probably will be), note where they came from for easier reassembly. Keep washers, grommets, spacers, and other hardware with their related screws. The additional hardware has been used for a reason, don't omit it when you reassemble the machine.

If necessary, write a list of the parts you remove and the order in which they were removed. If a certain screw has a rubber washer, a metal washer, and a locking washer on it, write down the order in which they are assembled on the screw. Carefully inspect the parts you remove to determine if they are aligned or oriented in a certain way. Indicate the alignment or orientation on your sheet so that you are sure to duplicate it when you put the machine back together again.

With the screws removed, gently lift off the top cover and be careful not to disturb the internal components or wiring. Once the cover is off, *you should not attempt to disassemble anything else inside the machine, except where noted.* Otherwise it could be difficult for you to reassemble and require an expensive trip to the repair shop. In addition, loosening the wrong screws can skew the orientation and position of critical components. This mistake might require a service technician (remember: $) and a special alignment jig (which you cannot easily get for yourself) to correct the mistake.

About static electricity

Static electricity buildup in your body might harm the integrated circuits and other components on the main circuit board. Therefore, do not touch any part unless you have first drained the static electricity from your body. If you plan to handle the circuit boards, use a ground strap around your wrist. The strap is available at most electronics supply stores (price: about $3). Follow its instructions for proper use.

Preliminary inspection

Take a few moments to acquaint yourself with the inside of the fax machine. Note the position of the optics, reader bar (if any), printhead, paper platen, paper transport mechanism, main circuit board, auxiliary boards for the front panel, and power supply. Avoid touching anything, especially the optics and printhead, unless you absolutely must (these two items are most fragile in your fax). Figures 5-7 through 5-11 show the innards of a typical fax.

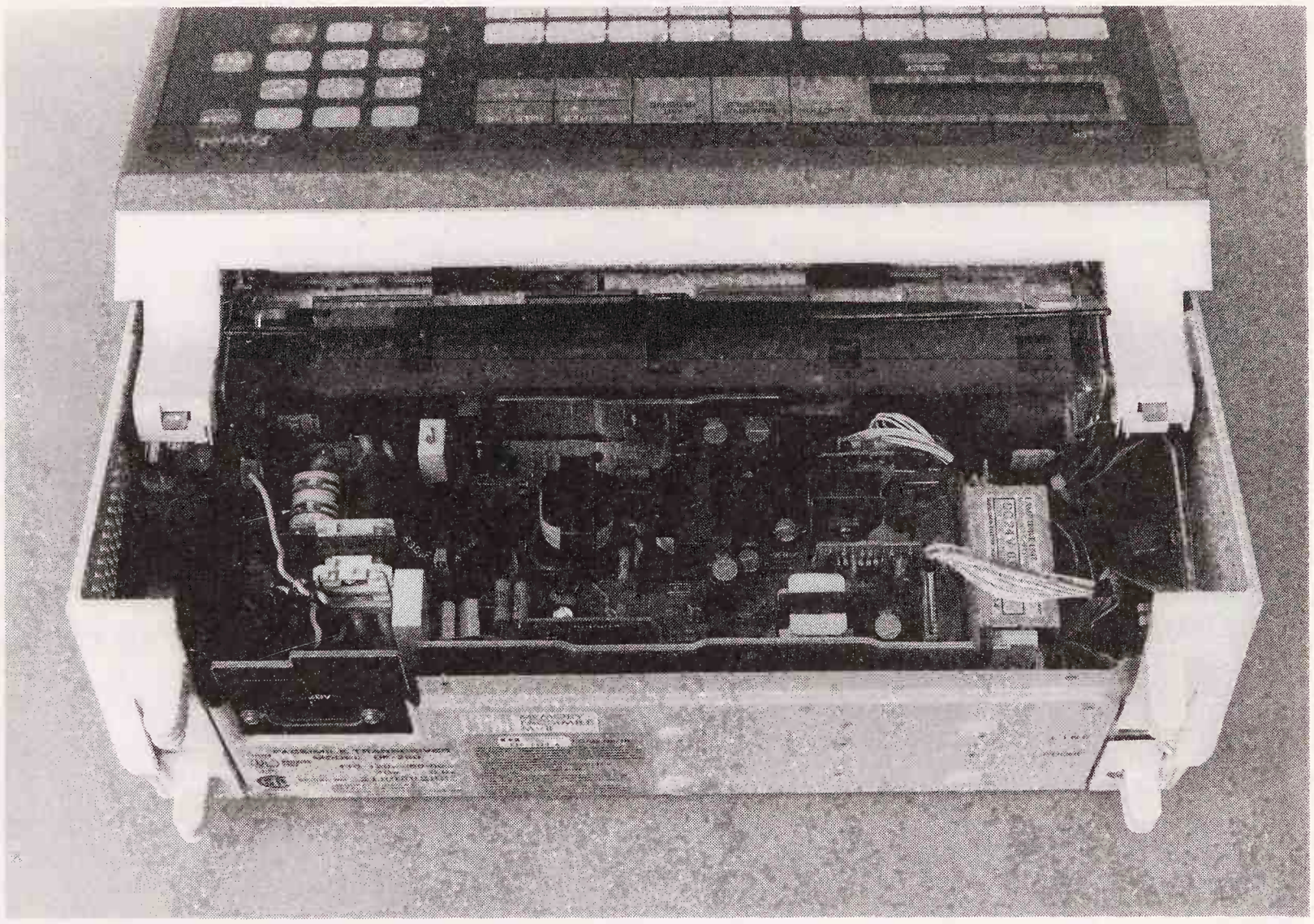


Fig. 5-7. An inside view of the top of a fax machine.

If you like, draw a picture of the insides of your fax, and note where things belong and how they work. When you are well acquainted with your machine, you will be able to service it better and more confidently. Especially notice the location and appearance of all the belts, tires, pulleys, fuses, and other mechanical parts. You might want to slip a sheet of paper in and watch how it passes through the machine. Note the action of all the parts.

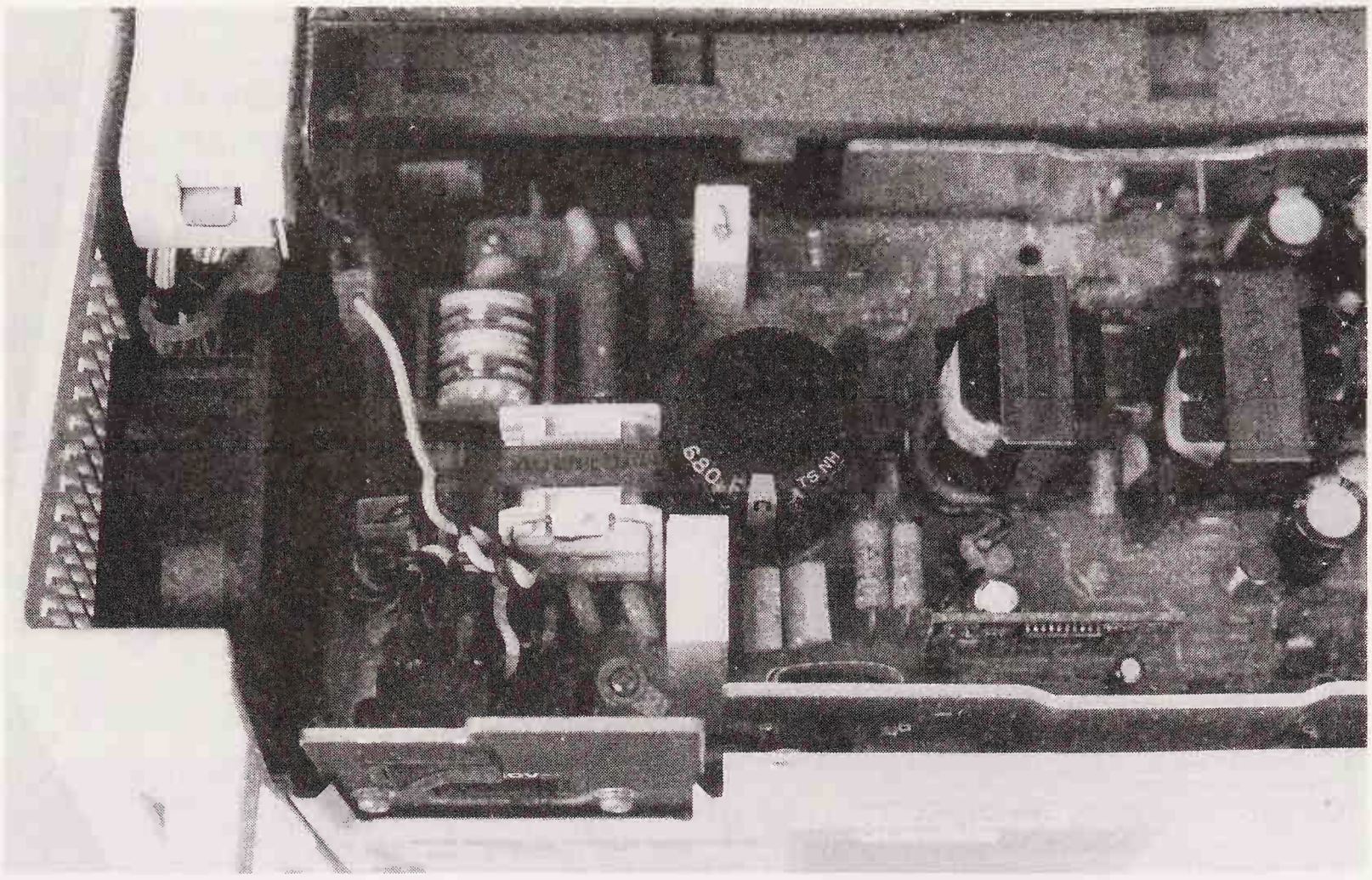


Fig. 5-8. View of power supply section.

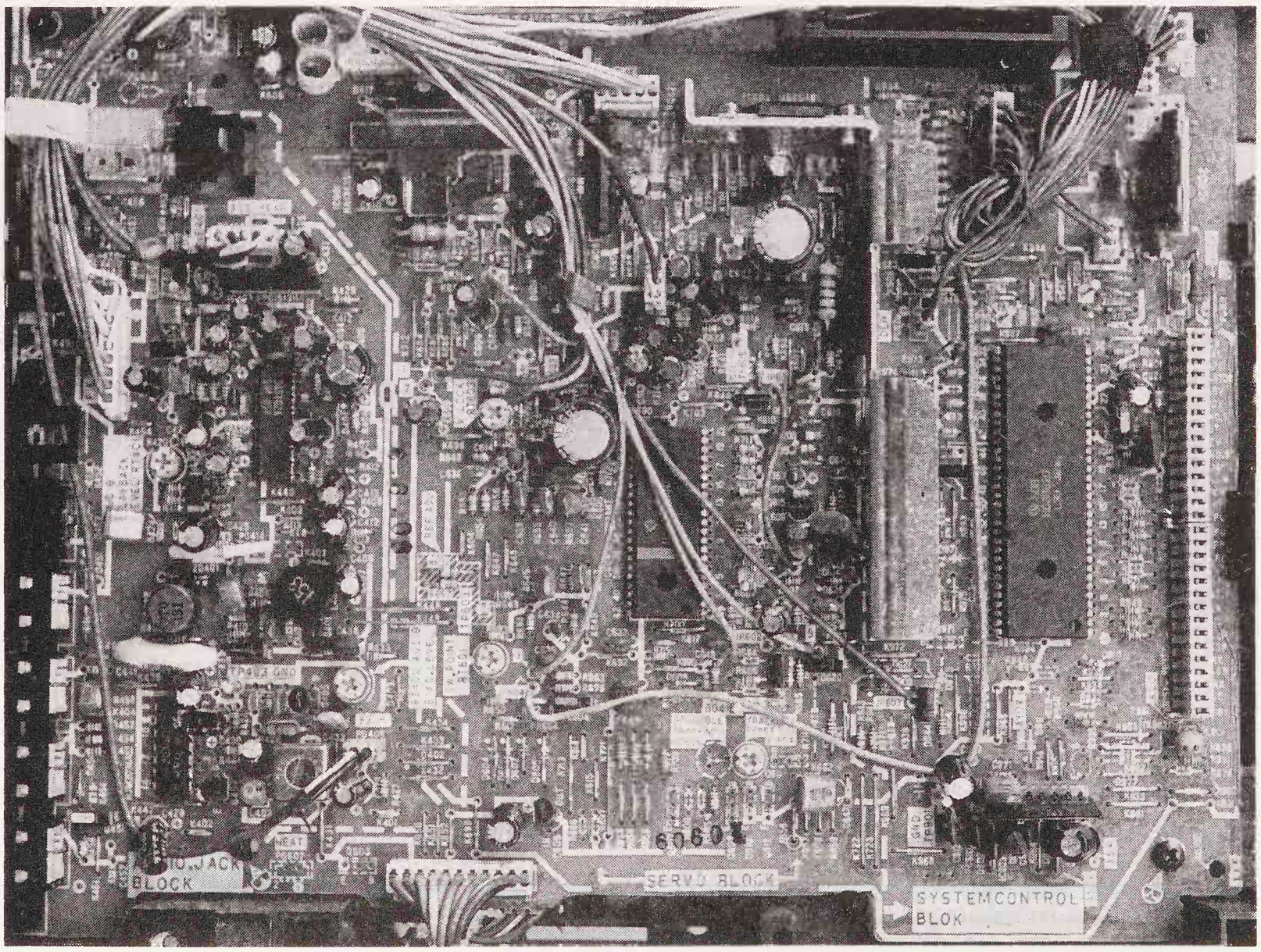


Fig. 5-9. View of main printed circuit board (PCB).

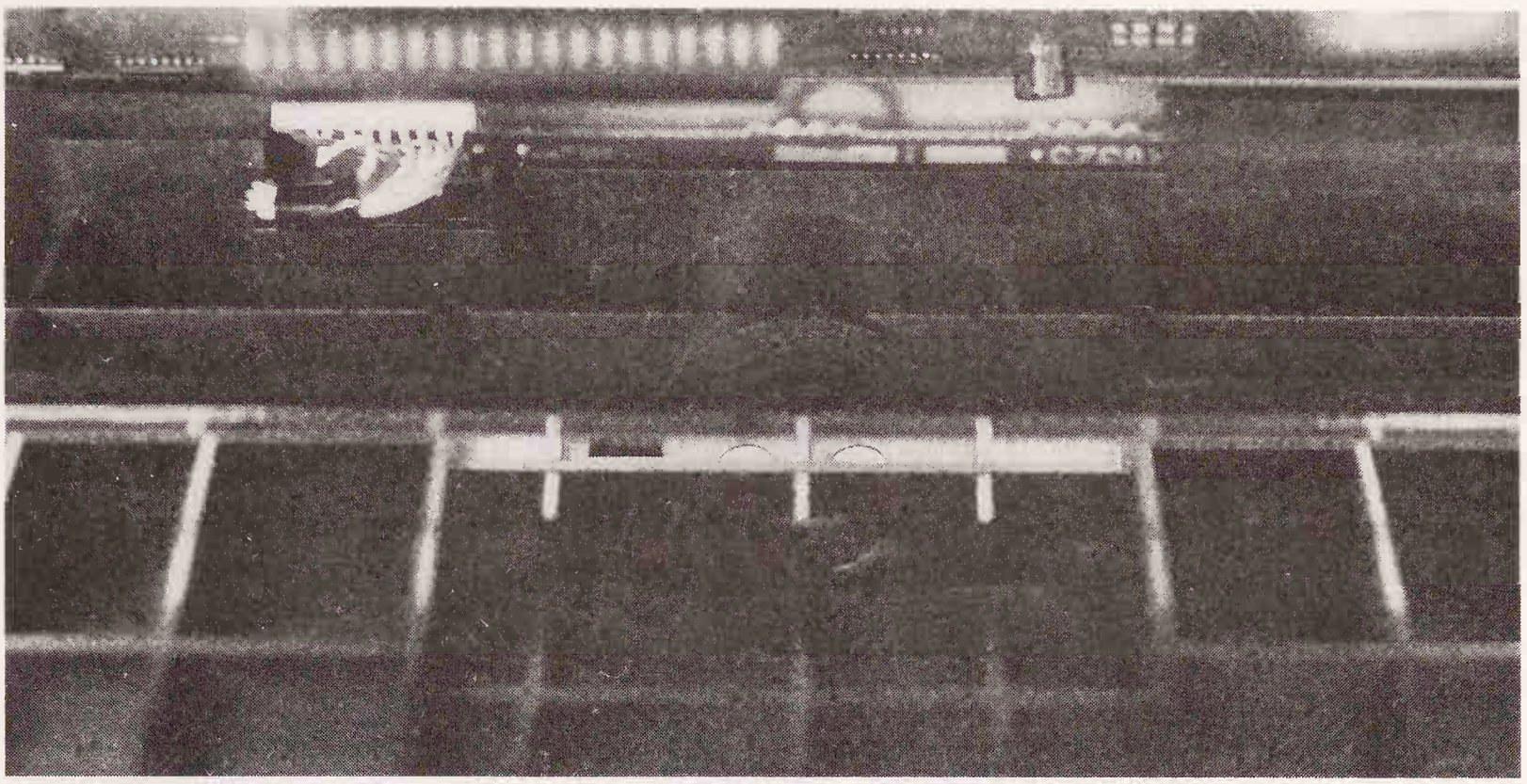


Fig. 5-10. A close-up of the optics section.

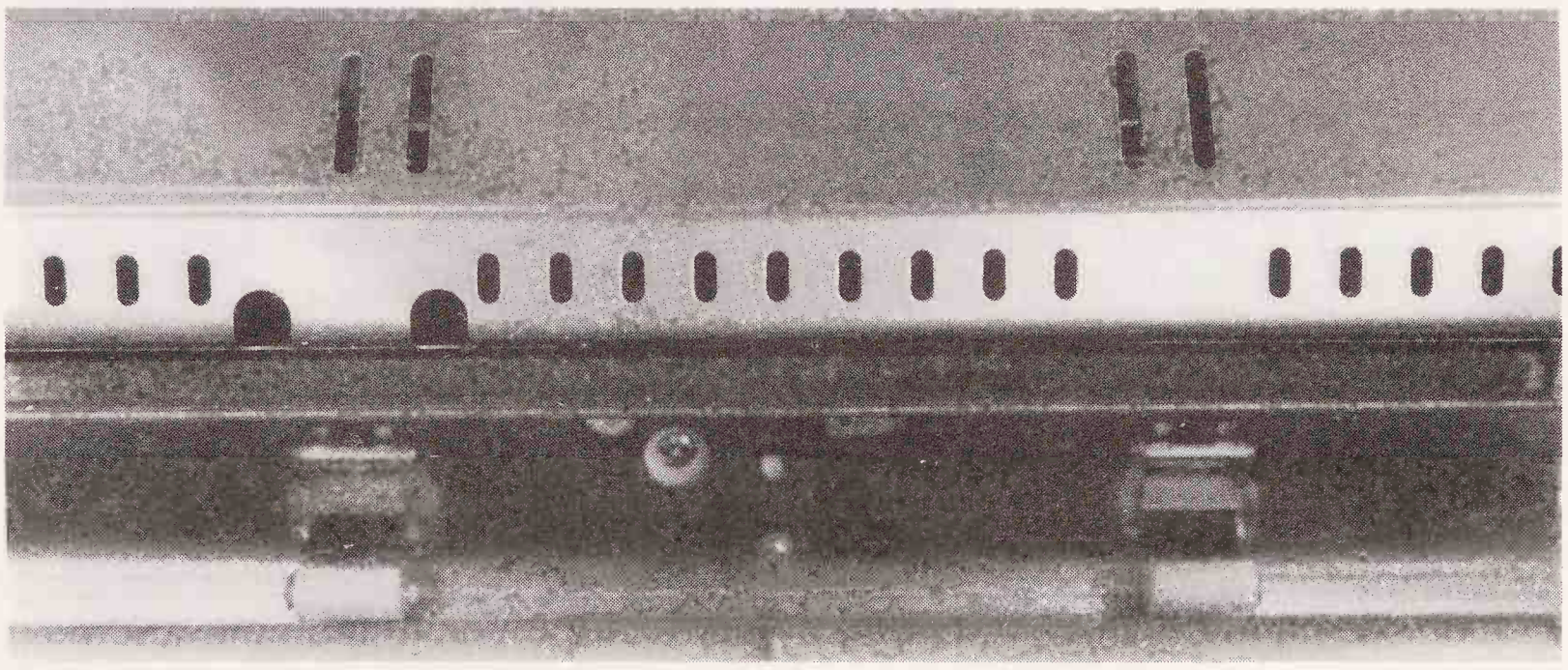


Fig. 5-11. A close-up of the printhead.

One word of caution: Avoid operating the machine in any position but upright. Don't turn the fax over or on its side—especially when paper is feeding through the mechanism. The paper might spill out and become jammed inside. Operating the fax in an abnormal position also poses greater stress on the motors and mechanical parts, which could lead to premature failure.

While the top (and/or bottom) of the machine is off, be particularly wary of the power-supply board or power-supply section on the main PCB. The filtering capacitors (which usually look like tall cans) retain some current even when the machine is turned off and unplugged. Avoid touching the leads of the capacitors and be sure not to short the leads together with a screwdriver or other metal tool. You might damage the capacitor and other components on the board.

Remember that little, if any, adjustment or calibration can (or should) be made once

you are inside the machine. Potentiometers (variable resistors) on the circuit boards are factory set and require an oscilloscope or special test circuitry for proper adjustment. The nature of fax machines inherently leaves few internal controls that you can safely tweak. In addition, the latest models are designed with few alignment points.

Platens, rollers, and belts

Visually check the rubber components (the paper platen, rollers, and belts) inside the fax machine. Overview diagrams of the location of these parts in the typical fax machine are shown in FIG. 5-12. If worn or cracked, the parts should be cleaned or replaced.

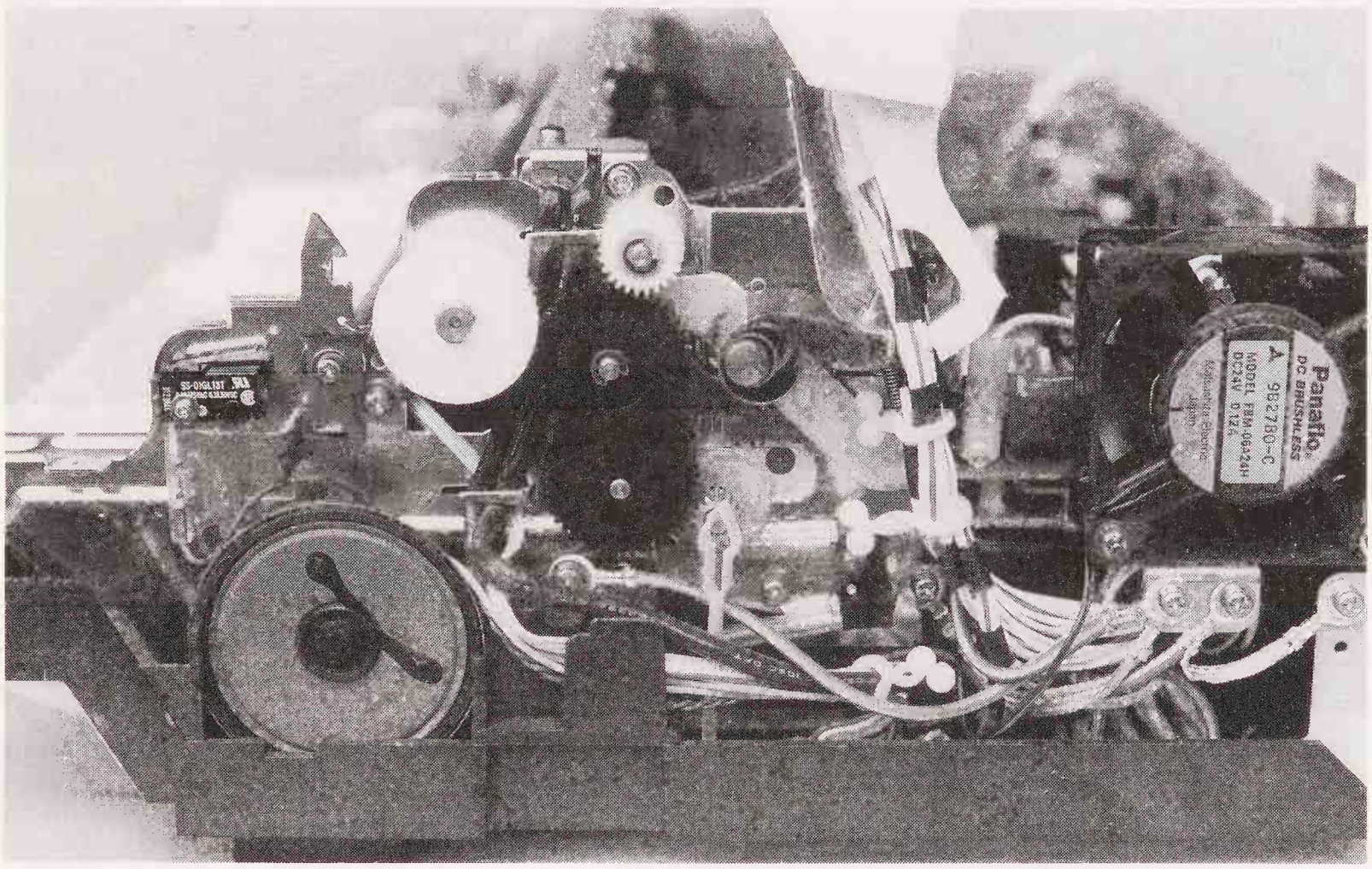


Fig. 5-12. Side view of rubber parts, with callouts of the important components.

To examine the rubber piece, you might need to stretch or twist it, as you would an automotive fan belt. A glazed appearance of the rubber indicates wear. Cracks show that the rubber is brittle and is no longer doing its job—it must be replaced. An oily film on the rubber can indicate that the fax was excessively lubricated, and that oil or grease from the mechanical sections of the machine have migrated to other components. The oil must be removed to restore proper traction. Healthy rubber is supple. With experience, you will learn to tell the difference between strong, healthy rubber parts and weak, sickly ones.

Rollers can develop flat spots—especially if the fax has not been used for some time. You can visually inspect for flattening. If the flattening is only minor, rubber rejuvenation might repair the damage. If the roller is excessively flat, it must be replaced.

You can replace worn belts. Obtain the service literature for your fax machine from the manufacturer, identify the part by its part number, and order it from the manufacturer. Belts can often be ordered simply by measuring the rubber's diameter and size. Dentist's picks, which you can buy at most electronics and surplus outlets, let you more easily remove and install belts that are hard to reach. Figure 5-13 shows a typical belt configuration as it is used in the paper feed drive mechanism.

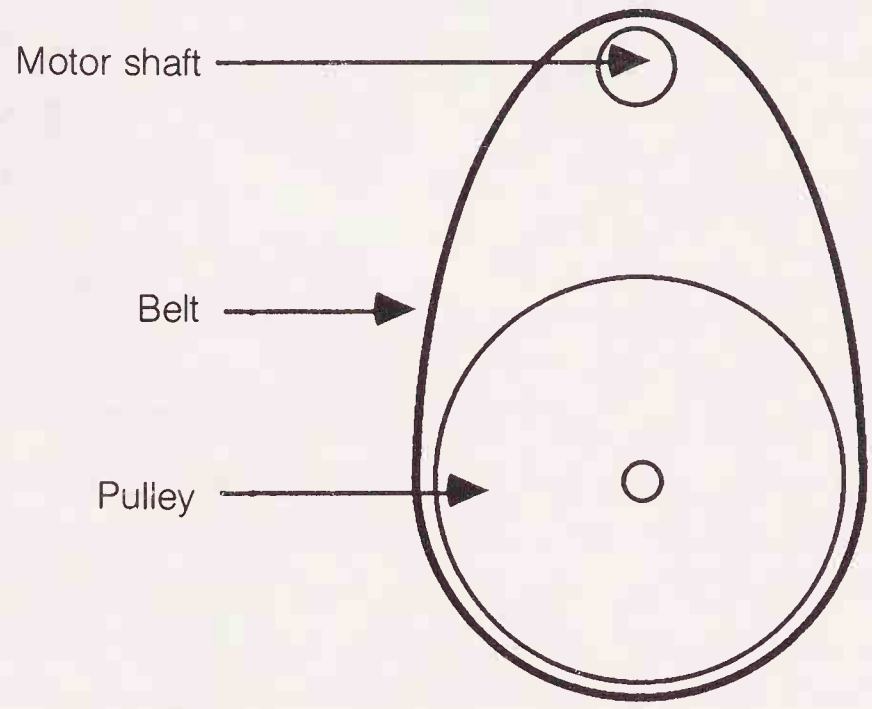


Fig. 5-13. The components of a belt drive.

Rubber rollers and belts that are slipping can be cleaned with Re-grip. This nonslip cleaner is available at many electronic supply and mail order stores (see Appendix A for addresses). As shown in FIG. 5-14, apply it to the belt or roller with a cotton swab or a sponge applicator. Wait a few minutes, then vigorously wipe it with a cotton swab. Use a disposable fingernail file to "sand" the old top layer. Scrape the flat of the board across the rubber in even, gentle strokes. Don't do more than one stroke at any one spot or you might flatten the roller.

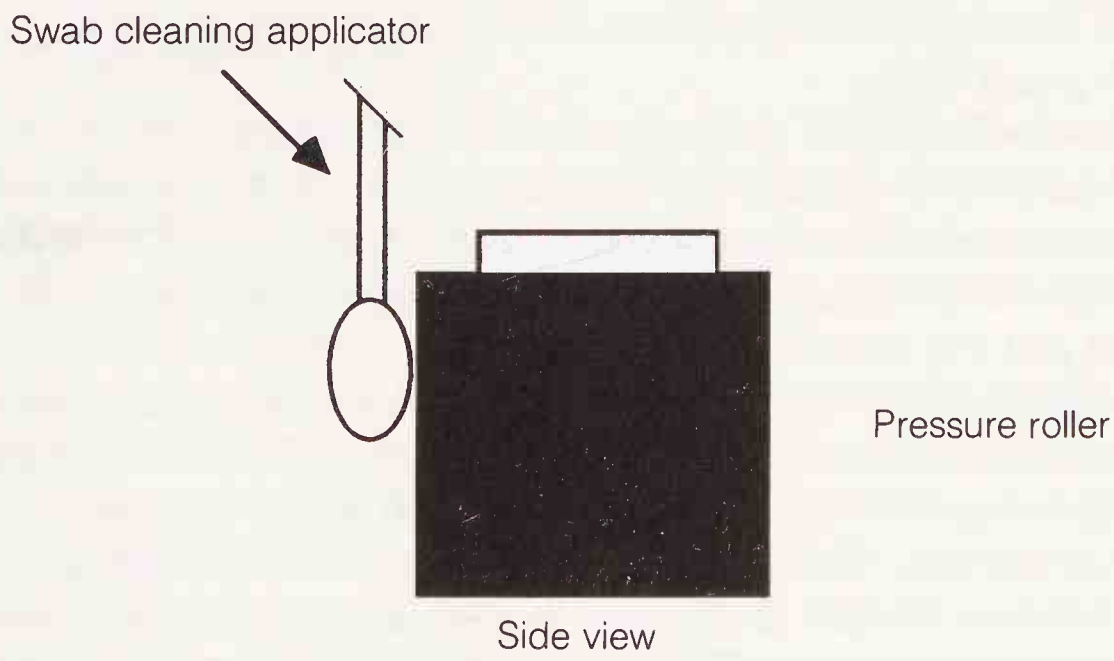


Fig. 5-14. Cleaning a rubber roller.

Don't use solvent-based cleaners on rubber parts, because these chemicals can prematurely dry the rubber or even melt it. Of course, never apply any kind of lubricant to a platen, roller, or belt, because this will defeat its purpose. If the rubber squeaks, something is not properly aligned or the rubber needs to be cleaned or replaced.

Platens, belts, and rollers often press against plastic and metal parts. After years of use, rubber can cake on these parts and cause a loss of traction. While you are cleaning the idler tires, belts, and the pinch roller, clean the surfaces that these parts come into contact with. Use alcohol or a nonpetroleum-based solvent to clean the part (if metal, use naphtha). Tough caked-on rubber can be removed with an orange stick from a manicure set.

Topical cleaning

Dust, dirt, and nicotine from cigarette smoke can accumulate in the interior of the fax machine and it should be removed. Use a soft brush to wipe away excess dust and dirt. If a lot of sediment exists, use a small hobby vacuum cleaner.

The remaining dust and other junk can be blown out of the insides of the fax. Purchase a small can of compressed air at a photographic shop (about $3) and liberally squirt it inside the machine. The air should free most everything that shouldn't be there. Remember to keep the can upright, because the propellant might drip out. Position the air flow so that debris is blown out of the fax, not deeper inside!

When cleaning inside the fax machine, look out for small scraps of paper that have been torn off during a paper jam. These scraps might not be in the paper path, so subsequent uses of the machine might not result in more jams. However, this paper can cause considerable trouble.

For example, a little piece of errant paper that has been torn from the corner of an original, might stick to the reader bar. That small piece will block any image when the original is passed underneath during transmission. Each page you send will have a blank vertical stripe.

The scraps of paper can also lodge deeper and deeper inside the mechanism, eventually causing a serious jam that cannot be removed—except by dismantling the entire innards of the machine. It's a good idea, in fact, to look for pieces of torn paper after clearing every paper jam.

Avoid household cleaning sprays, because these not only can leave a residue that could impair the proper operation of the machine, but they are also water-based and might short out the circuitry. Do not use a cleaner that contains a solvent of any kind and *do not* clean the machine with an oilless lubricant, such as WD-40. This spray is nonconductive and will cause the machine to fail completely.

You can clean nicotine sediments and caked-on dirt with a cleaner that is recommended for application on mechanical and electronic components. Figure 5-15 shows such a cleaner being used on the main PCB board (apply the cleaner only after the machine has cooled after use). Some cleaners have a built-in degreaser that disperses oil buildup; these are fine for use in your fax, as long as they are designed for direct application onto electronic parts. Whatever cleaner you use, make sure it leaves no residue after drying (which usually takes less than 15 seconds). If the cleaner leaves a noticeable residue, it is unsuitable for use inside your fax machine.

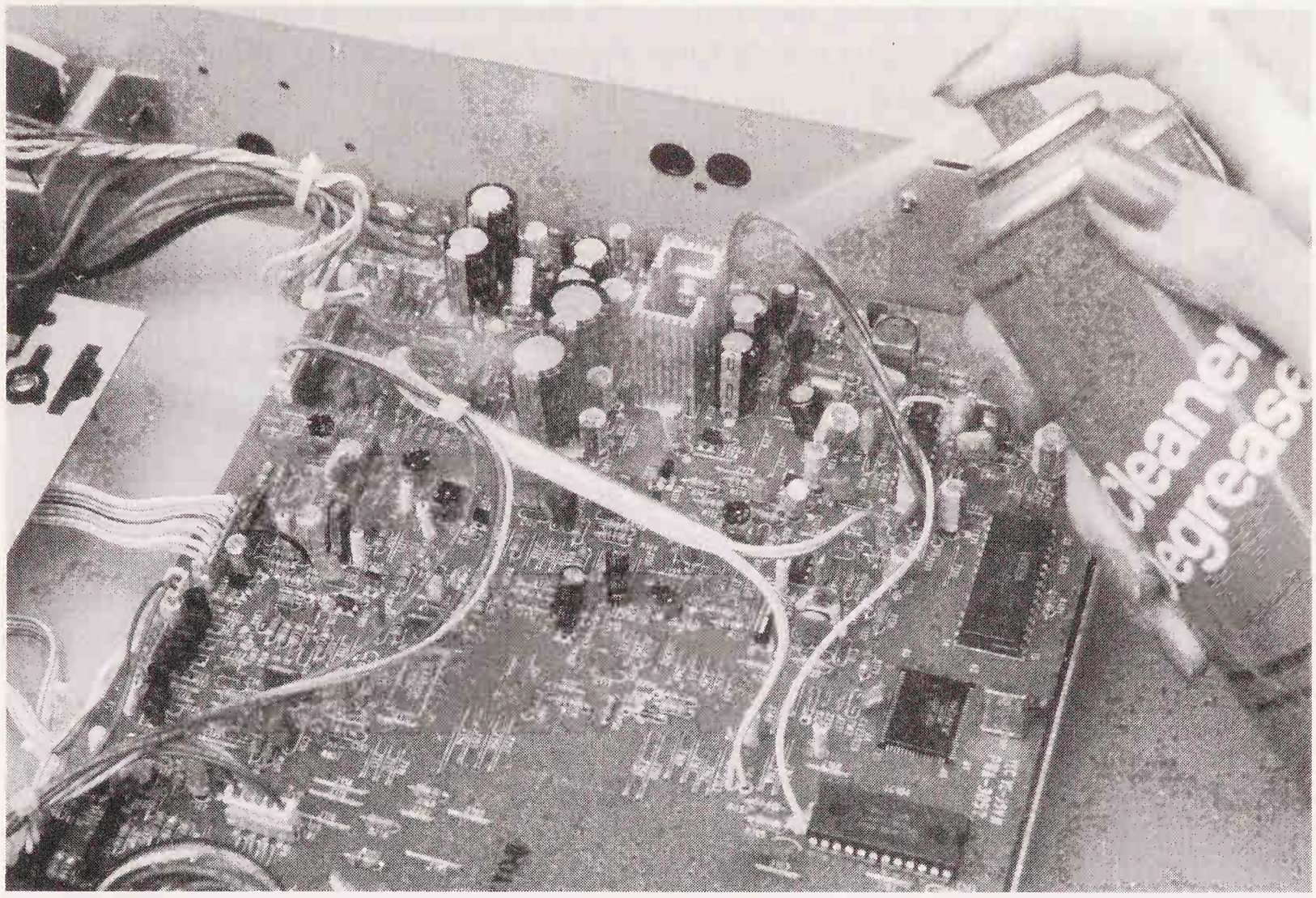


Fig. 5-15. Using an aerosol spray can for cleaning.

This cleaner is available at most electronics stores in spray form. You can use the pressure from the can to dislodge stubborn grime. Most cans have an extension spray nozzle tube. Attach the tube to the spray button and squirt into hard-to-reach places.

Prior to cleaning, be absolutely sure that the fax is unplugged from the wall outlet. Never use the spray near a live current. You could receive a shock or start a fire. After cleaning, wait at least three minutes for all the cleaner to evaporate before applying power to the machine.

Electrical contact cleaning

It's rare that the electrical contacts inside the machine will need to be cleaned. However, exposure to outside elements can quickly oxidize plated electrical contacts (that's why you should never place your fax machine near an open window where it might be exposed to the damp outside air). The contacts can also be contaminated by an accumulation of cigarette smoke.

If you see a heavy amount of oxidation or nicotine, carefully disconnect the wire that leads to the contact. Then, clean the contact with a commercially available contact cleaner and clean the exposed part of the wire in a similar fashion. If a heavy buildup of oxidation exists, scrape it off with an orange stick or nail file, then use the cleaner.

Most contact cleaner is in spray form and the spray might squirt the cleaner to an overly large area. If you only need to clean a small area, spray the cleaner into a cotton ball or swab, then use the cotton as an applicator. Be sure to leave no lint from the cotton on the contacts. If cotton threads are a problem, purchase some sponge-tipped

applicators, available from most electronics and many record stores. For very hard to reach places, use the extension nozzle tube. Figure 5-16 shows the contacts of a dirty power switch getting sprayed.

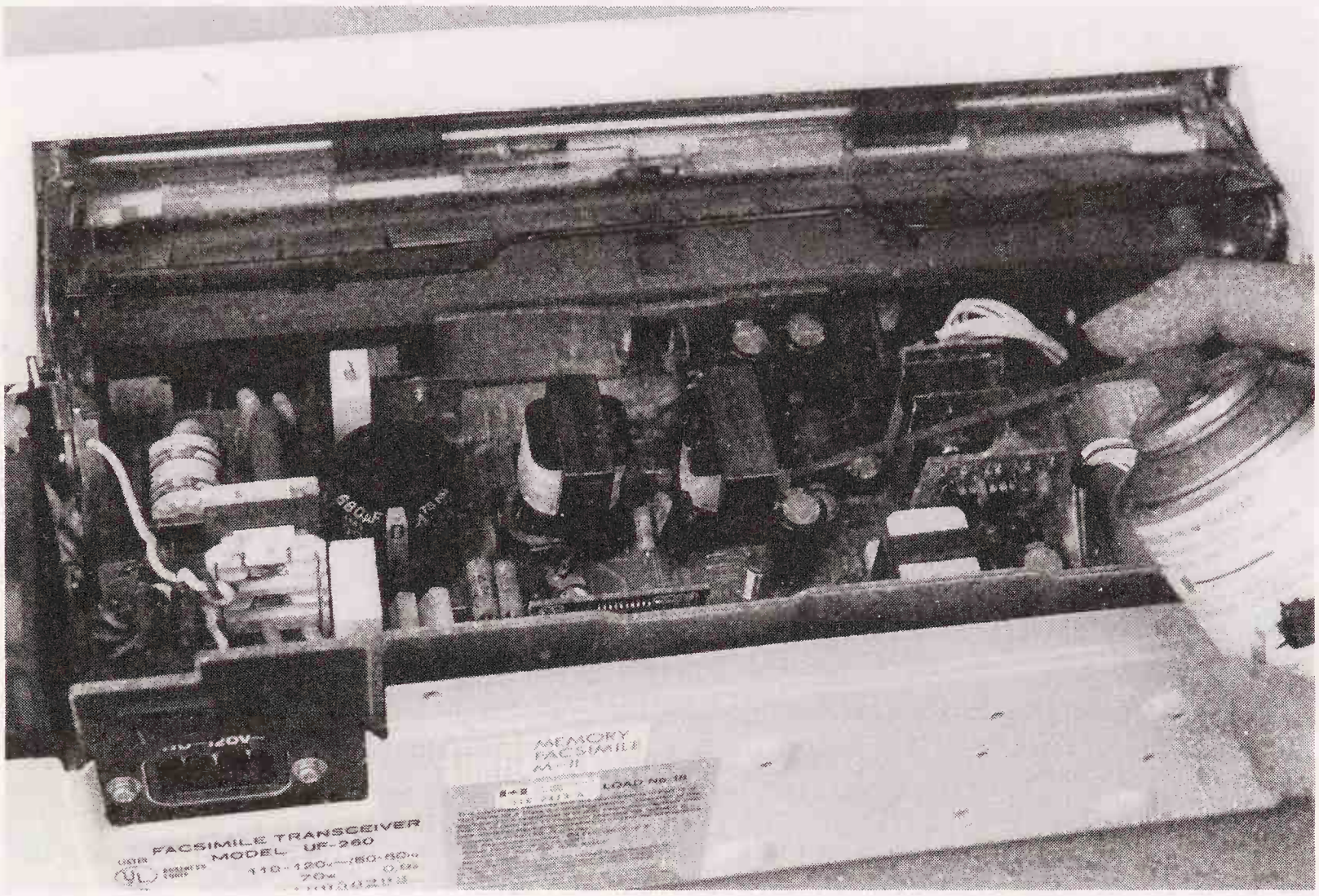


Fig. 5-16. Attaching an extension nozzle for pin-point cleaning.

Some circuit boards in the fax machine are connected to the main board by an edge-card connector. If you remove the circuit board for servicing or cleaning, be sure that you don't touch the the plated "lands" on the board or the connector pins on the main PCB. Not only could you damage a component with a shock of static electricity from your body, but the oils in your skin will act as a corrosive acid and diminish the effectiveness of the electrical contact.

Oiling and lubricating

Fax machines generally require little lubrication. After a year or two of use, however, it is advisable to apply small amounts of oil and grease to keep the machine in top-notch condition. At every major PM interval, you should lubricate such metal parts as the paper drive mechanism and mechanical linkages to the automatic document feeder.

You should also lubricate the mechanical parts if you clean the machine with a spray cleaner/degreaser. The cleaner strips any oil or grease from the moving parts. If you use the machine without lubrication, it might wear out prematurely.

When lubricating your fax:

- If it spins, oil it;
- If it slides or meshes, grease it.

Light machine oil is the best lubricant for spinning parts, such as the bearings of idlers and rollers. You should *never* use a spray-on lubricant, such as WD-40. Go easy on the oil and apply it only to the rotating part. Never oil the surface of a roller or where the lubricant might contact paper or rubber. Remember, more is not necessarily better. Excessive oil will gum up the paper and get transferred to the printhead and reader bar. Never apply oil directly to a motor. For small parts, apply the oil with a syringe applicator, as shown in FIG. 5-17.

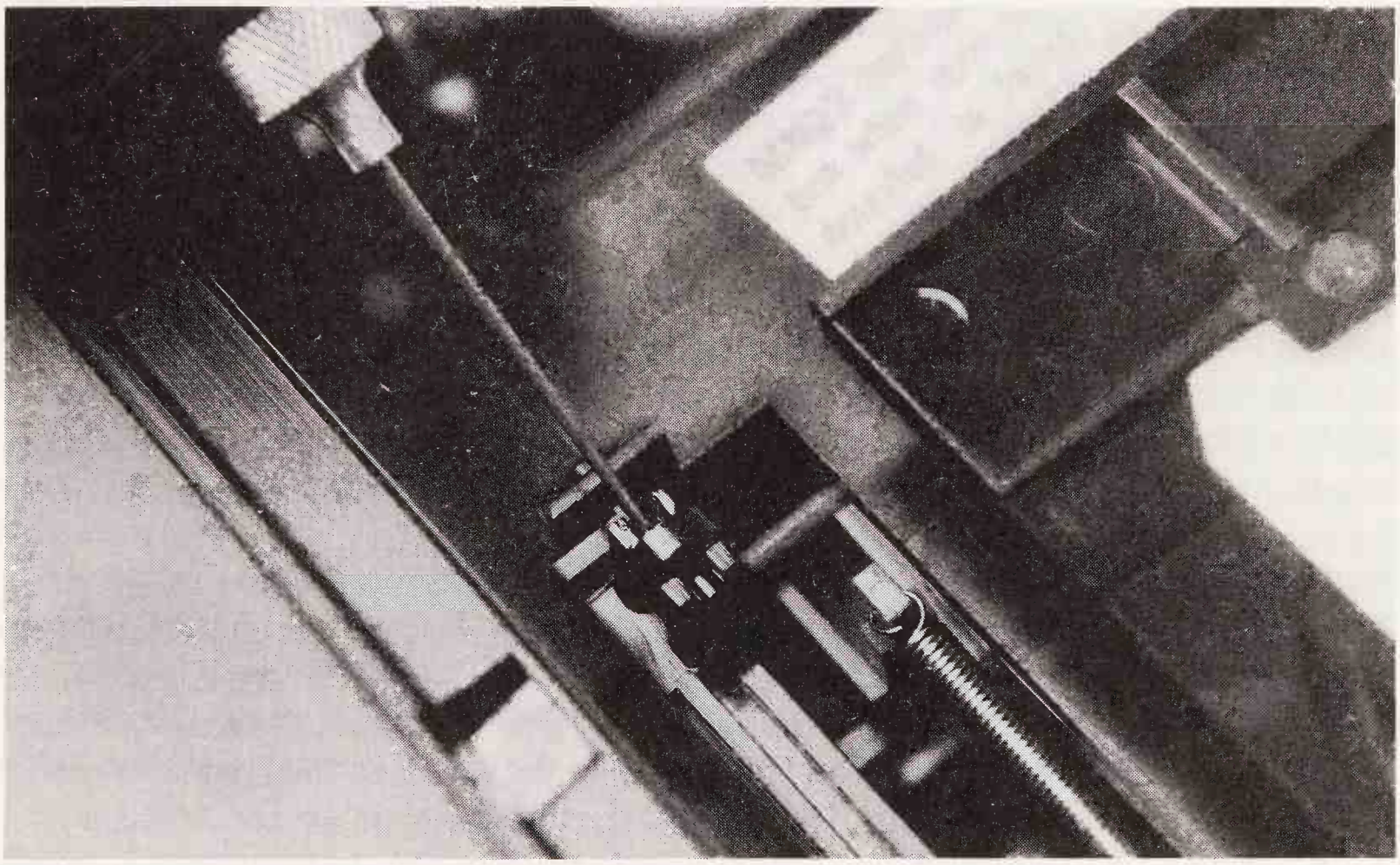


Fig. 5-17. Fax machines require little oiling and greasing. When lubricating a fax machine, use only light amounts of oil and grease.

A nonpetroleum-based grease is the best lubricant for sliding and meshing parts, the bulk of which are found in the paper transport mechanisms. This category includes cams, bell cranks, gear surfaces, and levers. As with oiling, apply only a small dab of grease. Spread the grease by moving or sliding the part back and forth a few times.

If the part can't be easily moved, or if it is geared down and won't budge, power the fax and insert some paper. To spread the grease, insert a test page and make a local copy (refer to chapter 3 for more details on the copy feature and how it can be used for fax maintenance).

Grease and oil should also be applied to any gears in the mechanism. As before,

apply a small dab of grease and cycle the threading mechanism back and forth to distribute the lubricant.

Cleaning the optics and reader bar

Most fax machines contain a number of front-surface mirrors and lenses that should be periodically cleaned. These optics are not sealed against contamination from dirt, dust, cigarette smoke, ash, and other grit. Because the optics are not in the paper path, they must be cleaned manually. In almost all cases, the optics can be accessed through the fluorescent light panel. You do not (and *should not*) need to disassemble the machine further to clean the optics.

Remove the screws that hold the panel and lift the panel, per the manufacturer's instructions. Use a photographic bulb brush to remove dust and other contaminants from the mirror(s) and lens. If the machine has seen much abuse, you might need to dust out the entire area to prevent the optics from becoming dirty again.

If the bulb brush won't remove all the impurities, wet a sponge- or chamois-tipped swab with lens cleaning solution (a mixture of Freon and alcohol, as is used in video head-cleaning kits). Gently wipe the surface of the optics with the swab. Let it dry for at least five minutes. Do not dry the optics with a cloth, because it could cause scratches.

Do not clean the optics in a fax machine with lens cleaner that is designed for eye glasses. Often, these cleaners contain silicon that could ruin the optics in your fax machine. Avoid the use of straight isopropyl alcohol, unless it is "technical grade"—less than five percent water (most over-the-counter isopropyl alcohol is 30 percent water). Let the alcohol dry for several minutes before you reinstall the paper and close the machine.

If your fax uses a long, flat reader bar, as opposed to mirrors and lenses (called *folded optics*), you can clean this bar with a suitable lens cleaning solution and gauze or sponge-tipped chamois. Use sterile bandage material for the gauze (never use anything that leaves lint). Buy the largest sheets you can find; you can always cut them down to size. Most gauze bandage material is multi-ply. Separate the layers so that you have two or three sheets sandwiched together. These layers should be enough for fax cleaning.

While the fluorescent light panel is removed, look for bits of paper, staples, paper clips, and other foreign objects that might have come off the originals when they were fed through the fax machine. Inspect the area around the fluorescent light and pay particular attention to any circuit board that are nearby. An errant staple or paper clip might cause a serious short circuit.

Cleaning the printhead

The vast majority of fax machines use thermal printing heads. As detailed in chapter 2, the printhead is stationary and consists of more than one thousand resistive points. An electrical circuit charges each point and makes it hot. As the paper passes over the printhead, the hot spots produce black specks on the page.

The printhead in most fax machines doesn't look like much, but it can handle a lot of abuse. It is generally copper or silver in color, bordered with green paint. The resistive points are difficult to see with the unaided eye.

Because the printhead contacts the fax paper, it can collect paper dust, label stickum, and other gunk that can impair operation.

The printhead should be accessible if you open the machine at its clam-shell hinge (open the fax just as you would to add more paper). The printhead is often located in the top half of the clam-shell cover, near the paper roll where the paper enters the machine; and is accessible without disassembling the unit. Or, the printhead will be located under a metal bar, where the receiving fax paper passes through. If you can lift the printhead off, do so. Don't disassemble the printhead assembly, because it could be difficult for you to correctly reassemble and align.

First, remove excess dust with a photographic bulb brush. Inspect the printhead closely and look for stubborn residue. If any exists, dampen a piece of gauze and run it back and forth across the printhead. Or, wet a sponge- or chamois-tipped swab and apply it gently to the surface of the printhead. If you use your fax for receiving five or more pages a day, you should clean the printhead every few months.

When cleaning the optics, reader bar, or thermal printhead, be sure to use only a soft, clean cloth. Otherwise, you could scratch the sensitive surfaces and cause permanent damage. Keep alcohol away from rubber parts. Alcohol dries rubber and leads to premature wear.

Using a fax cleaning kit

Some fax machines don't come apart easily enough to allow routine internal maintenance. Or, you might not enjoy the idea of dismantling your fax machine just to dust its insides. A fax cleaning kit, available at most office supply, computer supply, and fax stores, has nearly all the ingredients you need to keep your facsimile machine in top working order.

Look for kits that offer feed-through cleaning pads. With these, you feed the cleaning pad through the fax machine as if it was paper. The disadvantage to this approach is that the pad works with mild abrasive action. Avoid pads that have been soaked in alcohol. The alcohol is squeezed onto the rubber rollers inside the machine, which thereby reduces their lives.

Cleaning components in plain-paper and thermal-transfer faxes

Follow the same general steps when cleaning fax machines that use plain-paper or thermal-transfer printing technologies. Most plain-paper ("laser") fax machines also open in a clam-shell fashion: hinged at one end and opening to a large gap at the front or side. The clam-shell opening assists in changing the toner and other consumable items, as well as clearing paper jams.

Once the machine is open, use the soft brush to clear away paper dust, loose toner particles, and other contaminates. For best results, clean the inside of the fax machine every two weeks; every week if the unit is used for more than 100 pages per day.

Use a vacuum to suck the dust out or a can of compressed air to blow it away. However, don't blow the paper dust farther into the machine. Aim the can so the dust is shot outside, not inside.

When you clean inside the fax machine, look out for small scraps of paper that have been torn off during paper jams. These scraps might not be in the paper path (so subse-

quent prints are not jammed as well), but they can cause considerable trouble. For example, a little piece of errant paper might straddle the corona or transfer wires and cause the printouts to be light, or even completely blank! The scraps of paper can also get lodged deeper and deeper inside the printing mechanism and eventually cause a serious jam that cannot be removed, except by dismantling the entire innards of the machine. It's a good idea, in fact, to look for pieces of torn paper after clearing every paper jam.

Don't use cleaning solutions inside the fax machine. These solutions remove necessary lubrication. Additionally, if the solution leaves a residue, it could cause problems in operation.

Toner cartridge replacement

Plain-paper fax machines use black toner to print an image onto paper. In most units, the toner is contained in a replaceable cartridge. This cartridge contains most all of the consumable items that are used to print pages. The cartridge includes:

- Toner, the black (or colored) powder that adheres to the page and produces the actual image on the paper.
- Developer roller, which is used in the process of transferring toner to the paper.
- Photoreceptor drum, a light-sensitive metallic-coated drum that receives an image from a solid-state diode laser and reproduces that image onto paper.

Other plain-paper fax machines don't use a centralized cartridge. Rather, you must change photoreceptor drum and toner (and sometimes developer) separately. This process is more involved and requires extra steps on your part, but it is generally cheaper.

Whether your laser fax uses replaceable cartridges or separate toner/developer/drum components, follow the manufacturer's recommended service interval and replace these items as directed. On most laser fax machines, the cartridge lasts 2,000 to 3,000 pages. An indicator on the cartridge shows you if it needs to be replaced. Or, replace the cartridge if you notice consistently poor print quality.

The cartridge replacements also are available with a new fuser pad, which you should also replace, as directed. A cleaning swab is included so that you can wipe loose toner particles from the thin corona wire, which is located at the bottom of the printing mechanism (see chapter 2 for details on locating the corona wire and other critical components in a plain-paper fax machine).

After replacing the cartridge, clean the inside of the fax machine to remove any extra loose toner that might have escaped from the cartridge or rubbed off the paper. Check around the fuser compartment (when the unit has cooled) for surplus toner.

If the machine uses toner bottles, replace them as indicated. Wipe or vacuum spilled toner to keep the machine clean and easy to use, so the printouts look better. Follow the maintenance procedures that are provided by the manufacturer on cleaning other internal parts, including rollers, fuser, and drum.

Thermal-transfer fax maintenance

Fax machines that use the thermal-transfer printing technology (as detailed in chapter 2) are almost identical to standard fax units. The major exceptions are that thermal-transfer fax machines don't use heat-sensitized paper and they require thermal-transfer ribbons.

Replace the ribbon when it is exhausted. When the thermal-transfer ribbon is used up, the prints are blank. Be sure to have extra ribbons on hand; nothing is like trying to receive a long, important fax, only to run out of ribbon!

Thermal-transfer ribbons melt a waxy ink onto the paper. Be sure to thoroughly clean the printhead to remove the wax residue. Inspect the printing area of the fax machine for any stray bits of ribbon. Clean these areas with a photographic bulb rush or a cotton swab that has been soaked in a Freon/alcohol cleaner mixture.

Memory battery

Most fax machines use batteries (to store phone numbers, journal data, and so forth), which are known to leak. Periodically check the battery in your fax machine to be sure it is fresh and not leaking. Battery electrolyte is generally dark brown in color, but the corrosion effects of the electrolyte could cause a white powdery substance to accumulate around the battery. Look out for this substance and replace the battery if you see signs of leakage.

If the fax machine uses a long-life internal battery (typically lithium or mercury), you might need to partially disassemble the fax to get to the battery. Read the manufacturer's instructions first, before you attempt to take the fax machine apart. You might be able to access the battery from the paper compartment, or the fluorescent-lamp compartment.

Replacing a long life battery might not be an easy task. Often, the battery is enclosed in a convenient battery holder: just snap the old battery out and install a new one. However, in a few cases, particularly with the bargain fax machines, the battery is soldered directly onto a printed circuit board. Desolder the old battery, then resolder a new one.

Refer to Appendix C for more information on the art and science of soldering. You can also refer to a more complete reference on soldering and electronics; see Appendix B.

Paper cutter maintenance

A paper-cutting guillotine is found on most all mid- and high-end fax machines (they are beginning to appear on a number of low-cost fax units as well). After printing a page, the paper cutter chops the receiving paper to size. This way, you don't have to be content with a long roll of paper that you have to cut into sheets.

The paper cutter generally needs no cleaning, but periodically check that no paper bits are caught in it. Clean it with a cotton-tipped swab that has been dipped in a residue-free Freon/alcohol cleaning mixture.

If you use your fax machine heavily, the paper cutter could dull in time. If the cutter slices the page, but the cutting isn't complete, or if the cutter merely creases the paper,

then the cutter is probably dull. Resharpening the cutter is not recommended; it will have to be replaced. You can refer this job to a qualified tech or attempt the job yourself. Be extra careful though: the cutter requires careful alignment and replacement jobs aren't as easy as they look. Fortunately, it's a job you won't likely have to do.

Testing fax operation

After you've cleaned your fax machine, take a moment to test its operation. Reload the paper, close the machine, and insert a sheet in the document feeder. Press the COPY button (if your machine is so equipped). If you've done everything correctly, the original should feed into the machine without jamming. The copy should be dark and unblemished. Listen for tell-tale sounds of paper jams, such as crinkling and chattering rollers. Stop the machine immediately if a problem arises.

The local copy test ensures you that the reader bar and the printing mechanism is working correctly, since both are in action. The test doesn't include the transmission circuits of your fax. For that, you'll need to actually connect with a remote fax and transmit a sample page.

Front panel controls

The front panel operating controls seldom need preventative care, unless the fax has been subjected to heavy doses of dust, dirt, damp air, and/or cigarette smoke. You can clean the bulk of the control switches with a brush or with compressed air. The control panel in most machines uses sealed membrane switches, so the internal switch contacts are not affected by dirt. The membrane switches are located behind the actual switch button, as illustrated in FIG. 5-18, which you push when operating the unit.

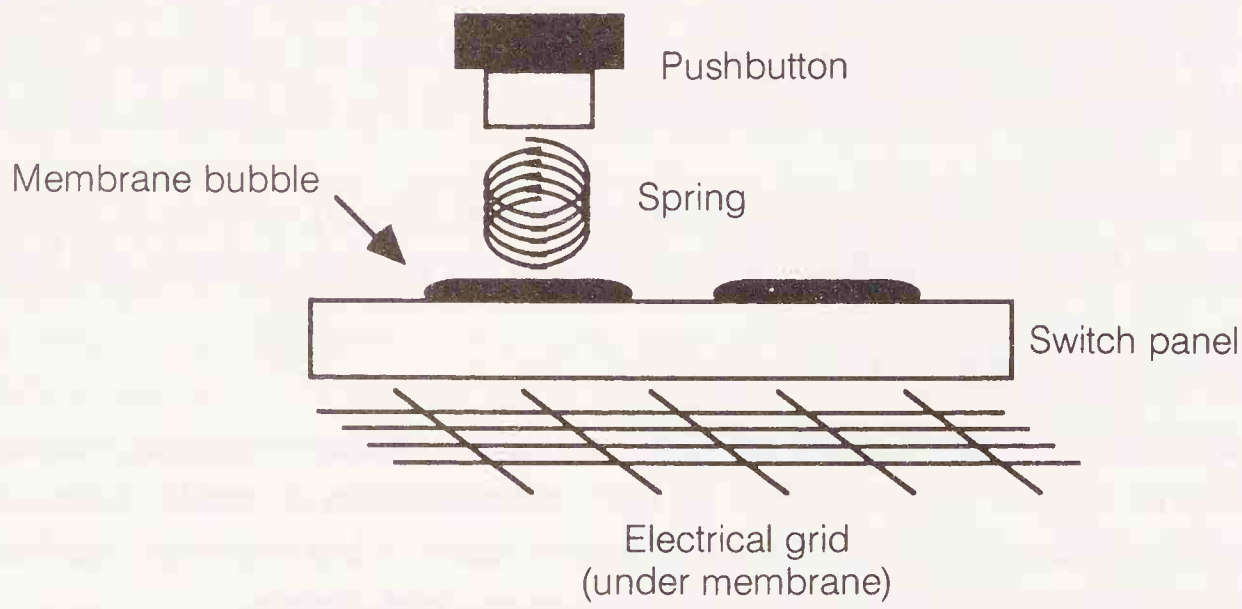


Fig. 5-18. How a membrane switch works.

If the switches in your fax machine are the regular open-contact type, you might need to apply a small amount of electrical contact cleaner to dispel the dirt. Again, you need not perform this procedure unless the fax machine has been exposed to heavy amounts of contaminants or if the controls are not working properly.

The contact cleaner dries quickly without leaving a residue. Nevertheless, you

should wait several minutes after cleaning before you turn the machine on and attempt to use it. As usual, never clean the switch contacts when the machine is turned on or plugged into the wall socket.

Final inspection

Before you replace the cabinet, doublecheck your work. Like the bumbling surgeon who leaves objects inside people after an appendix operation, don't leave tools, hardware, used cotton swabs, or cleaning supplies inside the chassis of the fax. Make sure that you have properly replaced all parts.

Reassembly

If all looks satisfactory, replace the covers and reassemble the machine with the screws you removed. Be sure the covers are aligned properly before tightening any of the screws. When all the screws are in place, tighten them lightly. Do not over-tighten or you might strip the threads of the screw and chassis.

Reinsert the paper properly. It's a good idea to cut the first five or six inches off the paper to avoid any curl that could cause jamming.

Checkout

After every PM interval, check the fax for proper operation. You should use a clear, clean original and make a local copy with the COPY function of the fax (see chapter 3 for details). Remember these operational points during the checkout process:

- The fax paper loading mechanism should operate smoothly and accept the paper as it should.
- The automatic document feeder should pick up the pages without mishap (try the sequence several times).
- The copy should be made properly, without smears, drop-outs, or voids.
- All the front-panel functions should work, including dialing (call a test number).
- The journal printing functions should work properly (on machines with such features).
- The paper cutter (if so equipped) should cut the paper cleanly and evenly.

Maintenance log

You might wish to keep a log book of all the maintenance checks and cleaning you've performed on your fax machine. Use the sample log form that appears in chapter 9 or make your own. In your log, be sure to note the exact checks and maintenance procedures that you performed and when you performed them.

If you have replaced any parts (like platens, rollers, or belts), record their part numbers in the log, and any troubles you might have had when installing them. By keeping a thorough log (FIG. 5-19), you can better estimate the timing of the preventative maintenance intervals for your specific machine.

Light use

PM (Months)	3	6	9	12	15	18	21	24	27	30	33	36
Clean/dust exterior/interior	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■
Clean printhead/optics	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Lubricate transport	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	■
Clean rubber parts	☐	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	■
Clean remote battery terminals	☐	☐	☐	■	☐	☐	☐	■	☐	☐	☐	■
Clean connectors	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■

Medium use

PM (Months)	3	6	9	12	15	18	21	24	27	30	33	36
Clean/dust exterior/interior	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Clean printhead/optics	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Lubricate transport	☐	☐	☐	■	☐	☐	☐	■	☐	☐	☐	■
Clean rubber parts	☐	☐	☐	■	☐	☐	☐	■	☐	☐	☐	■
Clean remote battery terminals	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■
Clean connectors	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■

Heavy use

PM (Months)	3	6	9	12	15	18	21	24	27	30	33	36
Clean/dust exterior/interior	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Clean printhead/optics	■	■	■	■	■	■	■	■	■	■	■	■
Lubricate transport	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Clean rubber parts	☐	■	☐	■	☐	■	☐	■	☐	■	☐	■
Clean remote battery terminals	☐	☐	■	☐	☐	■	☐	☐	■	☐	☐	■
Clean connectors	■	■	■	■	■	■	■	■	■	■	■	■

Your machine

PM (Months)	3	6	9	12	15	18	21	24	27	30	33	36
Clean/dust exterior/interior	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Clean printhead/optics	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lubricate transport	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Clean rubber parts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Clean remote battery terminals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Clean connectors	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Fig. 5-19. Use this guide to set up your own preventative maintenance schedule.

6

Fax first aid

Accidents do happen—to even the most careful people and to their precious fax. If an accident befalls your facsimile machine (you spill your cup of coffee into it, for example), don't panic. By following some simple cleaning and checkout procedures, you can reduce or eliminate potentially costly repairs.

This chapter covers first aid treatment for a number of accidents and how you can repair all or nearly all of the damage yourself. Even if your fax machine is presently healthy and working fine, read through this chapter to acquaint yourself with the recommended procedures. You never know when they'll come in handy.

Tools and safety

Most of the repair procedures require at least partial machine disassembly. If you haven't done so already, please read chapters 4 and 5 for more information on how to take your fax apart and what tools you need to do the job right. Pay particular attention to the safety points in chapter 5.

The steps outlined in this chapter are designed to help you minimize the damage of accidents, not make them worse. If you are not confident in your ability to perform some of the repair procedures or if you lack the proper tools and cleaning supplies, then by all means don't try the procedures. When in doubt, refer to a qualified technician.

Dropped machine

Fax machines are not meant to be dropped off bookshelves, racks, tables, or car seats, but it happens. A drop onto soft carpeting might shake up the machine a bit, but not cause serious internal injury. A harder impact, however, might break or bend the cabinet, chip a piece of the front panel, or yank off the automatic document feeder.

A cracked cabinet or broken piece on the exterior of the machine can usually be mended with a strong adhesive. If the part is plastic, just about any clear glue that is recommended for use on plastic will suffice. After gluing, hold the pieces together with

your fingers until the adhesive sets. Or, tape the pieces together like a surgical suture until the glue is completely dried.

Checking for internal damage

After a fax has been dropped, even if no visible damage exists, inspect it carefully. Don't test it by plugging it in and running a copy. You might cause additional damage.

Quickly check if parts have come loose inside the machine: unplug the unit from the wall socket and gently shake it. If it rattles, you can bet something is bouncing around that shouldn't. Even if you don't hear loose parts, it's a good idea to disassemble the fax machine before attempting to use it. Follow the general disassembly instructions that are provided in chapter 5.

When the top cover of the cabinet is removed, look for the loose parts and ascertain where they came from. If the broken piece is plastic, glue it back with a suitable cement. Broken metal parts are harder to mend, but a number of metal adhesives might do the job. The alignment of internal parts is often critical to the operation of the fax, so make sure you have glued the repaired piece correctly.

While the top is off, visually inspect the interior of the machine for hidden damage—things other than completely broken pieces. Pay particular attention to circuit board(s), the paper feed mechanism, the printhead, and the optical assembly. If anything looks broken, bent, or out of place, return the machine to a qualified repair center. In the case of critical components (lenses, mirrors, and circuit boards), the parts usually cannot be repaired, but must be completely replaced. This procedure usually requires direct access to replacement parts as well as specialty tools and jigs.

Check the printed circuit boards inside the fax. If you see any hairline cracks, it's a bad sign—a broken printed circuit board must be replaced. Using the machine as it is might cause more damage, because components might be shorted. You could conceivably burn out the power supply, motors, and other costly parts by attempting to operate the fax with a faulty circuit board. Fortunately, however, a very strong jolt is required to break a circuit board, so it is not a common occurrence.

Broken wires

A strong impact might cause electrical wires and connectors to break or disconnect. Sometimes the connector, like the one in FIG. 6-1, is just jostled in its socket. Look very carefully at these, because some connectors might look okay from the outside, but the electrical contact inside has been broken. Press all the connectors firmly into their sockets just in case. If the connector has disconnected, plug it back in to its respective socket. However, check the proper polarity. Don't plug the connector in backwards!

Broken wires that lead to connectors and boards must be resoldered. If the solder joint is accessible and does not require precision work, you can fix it yourself. If you are unfamiliar with proper soldering techniques, refer to Appendix C for a quick lesson.

If more than two wires have come undone and it is not obvious where they go, consult the schematic diagram for your fax, if available, or return the machine to a service shop. Don't take chances. If two wires are loose, you have a 50-percent chance of soldering them back properly. You also have a 50-percent chance of soldering them in the wrong place. Not particularly great odds, considering what is at stake.

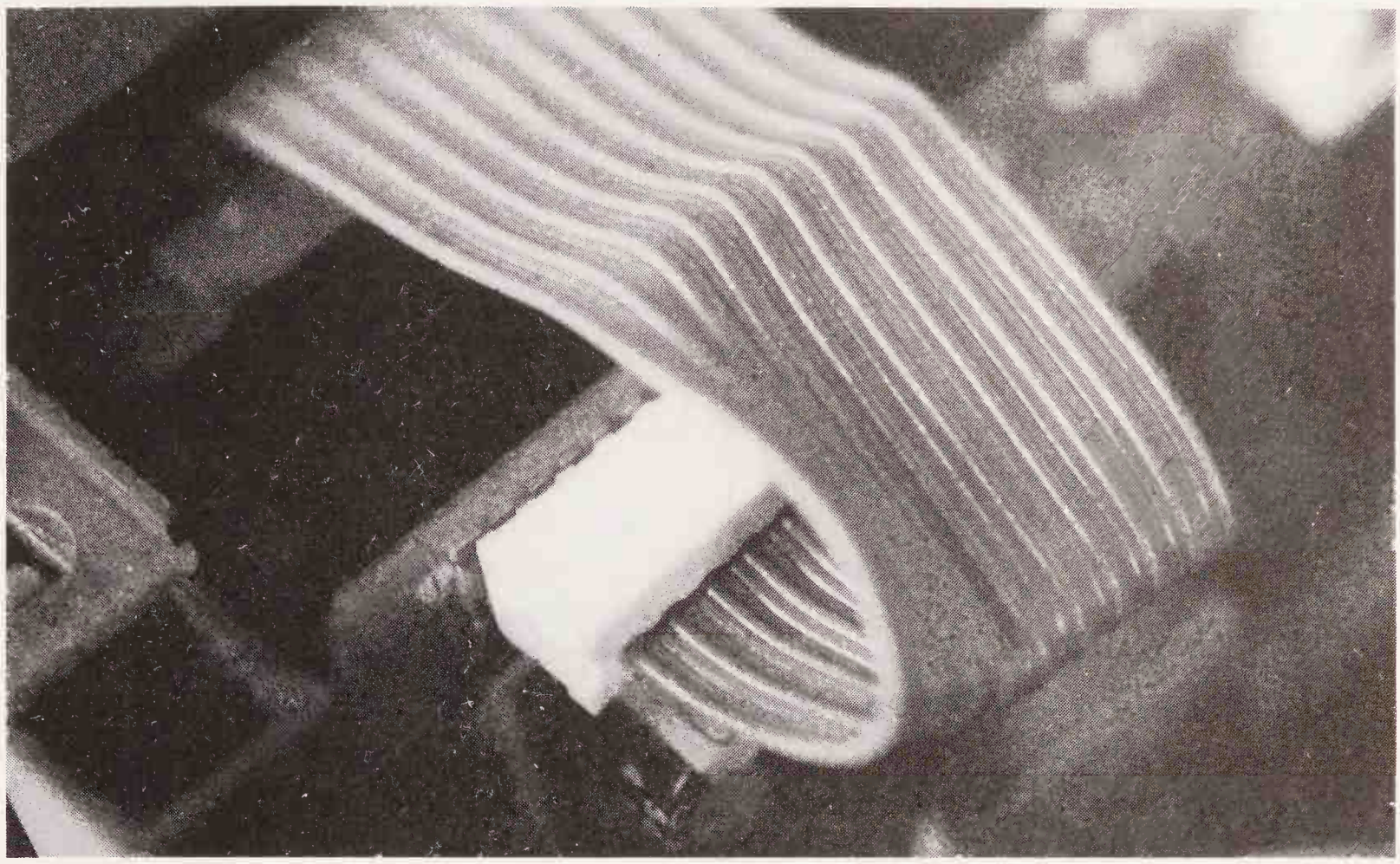


Fig. 6-1. Look for loose connectors inside your fax machine. Press the connector into its socket to reestablish electrical contact.

Leakage current test

Before turning on your fax, even if you do not take it apart to inspect for internal damage, be sure to check for possible leakage current. This test determines if any part of the ac line has contacted the metal cabinet or base. It is a safety check to prevent a potential shock hazard. You'll need a volt-ohm meter to perform the test.

With the fax unplugged, short the two flat prongs on the end of the ac cord, as illustrated in FIG. 6-2. On the meter, select the OHM function at a range of no less than 1 kohms. Connect one test lead from the meter to the jumper on the ac cord. Connect the other test lead to any and all bare (not painted) metal parts of the machine. For a typical fax, the meter will read about 50 to 100 kohms--if you get any reading at all.

A reading substantially lower than these ratings is a good indication that the power supply is contacting the metal parts of the unit. If this happens, inspect the power cord as it leads into the machine, as well as the on/off switch, the transformer (usually bolted onto the back of the machine), and the wires that lead from the transformer to the printed circuit board. If the wires are broken or are shorted to the cabinet, repair the fault before using the fax.

Fire damage

Fire damage includes the effects of both the heat and smoke. Intense heat can totally destroy the fax, of course, but even moderate heat (150 to 175 degrees) for even a short period of time can cause considerable damage to the machine's electrical and mechanical components. After a fire, check for obvious damage to plastic parts.

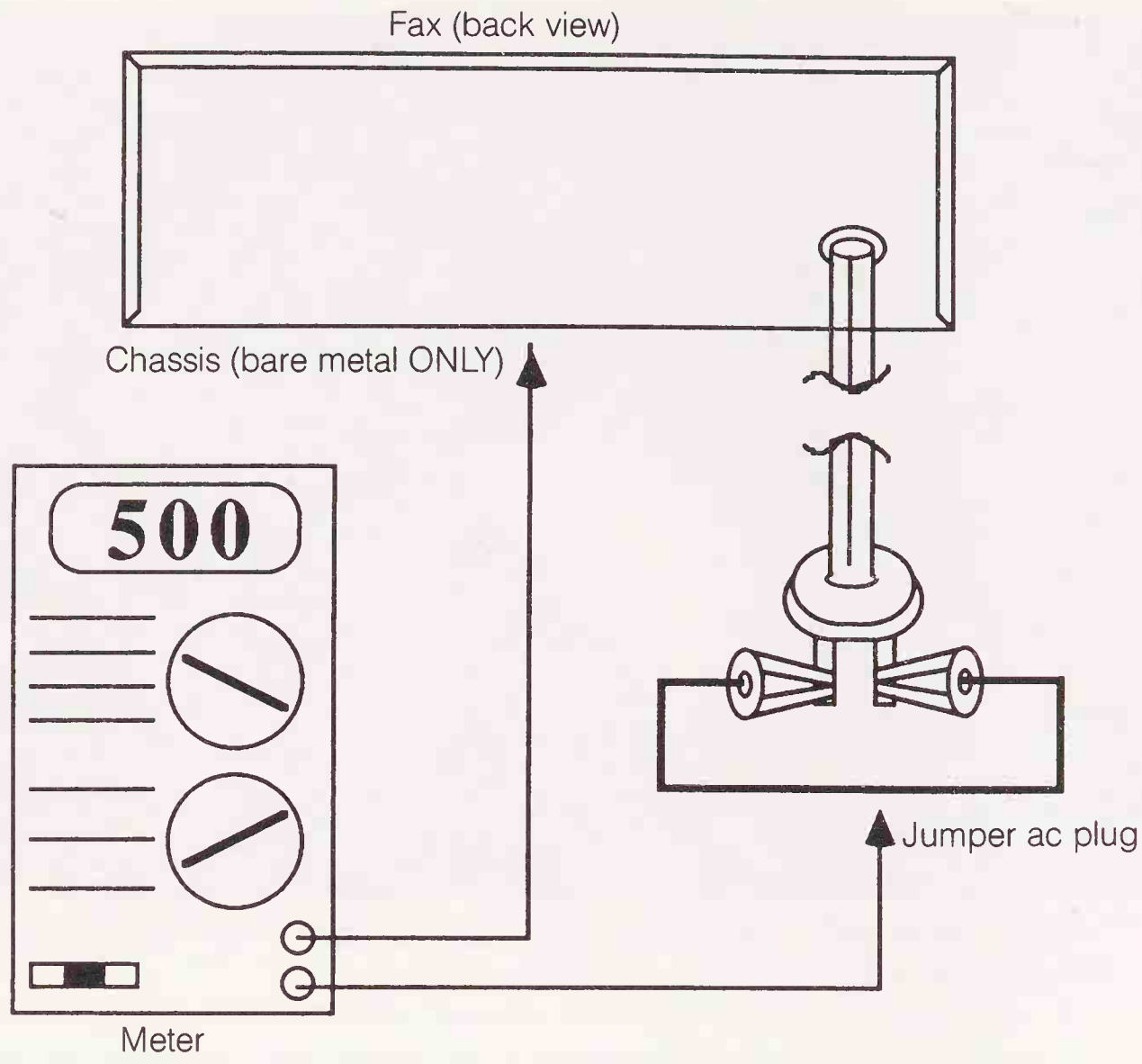


Fig. 6-2. How to perform the open leakage test.

If paper was in the machine, remove it and inspect it for warpage, discoloration, or other damage. You'll probably need to replace the paper if it was exposed to the heat of a fire. If the paper is visibly blackened (rather than just grayed), then the heat was probably high enough to damage other parts inside the machine. Disassemble the machine and inspect it thoroughly.

Minor warpage of plastic parts and expansion of metal parts can throw components out of alignment. You can test for warpage and expansion by inserting a page in the document feed and making a copy. If anything is out of alignment, such as the paper mechanism, or the optics, the copy will be impaired, with streaks, spots, or distortions (if you get any image at all). Perform this test only after you have thoroughly inspected the machine and are certain that powering it up won't cause additional damage.

Smoke damage

Many people erroneously think that heat from a fire causes the greatest damage. Insurance companies will tell you that smoke, not heat, is the worse enemy. Why? The smoke gets everywhere—even in rooms that were not touched by the fire itself. The black soot of smoke cakes on everywhere and has an acidlike effect that can eat through finishes and protective layers. Even if your fax does work after a fire, failure to remove the layer of soot in its interior might cause considerable damage later. The optical components in the fax, including lenses and mirrors are especially susceptible.

If you are the victim of a fire, promptly clean your fax (and other electronic gadgets

for that matter) as quickly as possible. You might want to take a Polaroid® or other snapshot of the machine for insurance purposes. Generally no need exists to leave the fax machine in its damaged state just for the insurance claim; in fact, cleaning it promptly reduces the chance of more serious damage over time. Thoroughly wipe the outside of the fax with a damp sponge, which will pick up most of the soot.

Matters are a little different on the inside of the machine. Don't use a household cleaning spray on the mechanical and electronic parts of the fax—partly because the cleaner is water-based (and poses a potential short-circuit hazard), and partly because it is not really effective in cleaning hard-to-reach places.

A cleaner/degreaser spray can be used to thoroughly clean the inside of the unit. Spray the cleaner heavily to remove the soot. Use the extension spray tube (usually included with the can) to get hard-to-reach places. The cleaner will evaporate after 5 or 10 seconds. If soot remains, spray again. If the smoke buildup is heavy, spray the cleaner on and brush it off with a small painter's brush.

The cleaner/degreaser leaves no residue, but it might remove the lubrication on some of the mechanical parts in the machine. After using the cleaner/degreaser, lubricate the fax, if necessary, following the instructions that are provided in chapter 5. Remember that fax machines, on the whole, require little lubrication.

If you're not sure if a part needs oiling or greasing, try using the machine for a while. Leave the top cover off and watch its operation carefully to see if lubrication is necessary.

Finally, the optical components and printhead should be cleaned thoroughly as well. Carefully follow the cleaning procedures in chapter 5. You will need to apply liquid cleaner to the optical components to remove the soot from the fire. Do not try to brush away the soot with a dry brush, because it could scratch the lenses and mirrors.

Water damage

Each year, water does more damage to personal property than fire. Even if you don't live in a flood basin, your fax machine could still be subjected to a drink. Something might spill into it, such as water, coffee, or soda pop. It's happened before and it'll happen again.

If your fax is ac operated, and it becomes wet, *immediately* unplug it. If it is unsafe to reach the plug, turn the power off at the circuit breaker or fuse box. Do not touch a wet fax; you could receive a bad shock. If the unit shorts out when water spreads inside its cabinet, it is probably seriously damaged and it should be taken to a repair shop for proper service. If no sign of immediate short-circuit damage is visible, you can minimize any further problems by tracing the following steps.

Removal of excess liquid

First, soak up the excess liquid. Use paper towels to blot up the extra. If any liquid has seeped into the machine, you must disassemble it and remove the drops and puddles from the inside as well.

If the machine was dunked into fresh water, just wait until the remaining moisture evaporates. Some water might be trapped under components, so even if the surface of

the circuit board and internal parts are dry, water might still be lurking underneath. You can use a hair dryer (on low or no heat only) to help speed up the drying process. Do not dry with high heat, because you might warp some parts. Even after the water is gone, some moisture might still be present, particularly on smooth metal parts, such as the printhead. Allow another two to three hours for condensation to evaporate.

You can test for remaining moisture by placing the fax machine in a plastic garbage bag. Seal the end and place the bag overnight in a warm, dry place. If moisture remains in the machine, condensation will form inside the bag. It's a clue to let the machine dry out some more.

Removing sticky or staining liquids

If the fax machine was subjected to sticky or staining liquids (salt water, coffee, soda pop, milk, etc.) you need to thoroughly clean the unit inside and out. This maintenance prevents the liquid residue from interfering with the operation of the machine (salt water will corrode the metal parts, for example). If the liquid is thick, use a damp sponge to wipe up as much as possible.

Next, thoroughly spray the fax with a cleaner/degreaser, as mentioned in the previous section on fire damage. Apply the cleaner/degreaser until all signs of the residue are gone.

Because the cleaner/degreaser is not water-based, you can also use it to remove any water that might remain in the machine. The cleaner/degreaser will displace the water and remove it from even hard-to-reach places.

After cleaning, moving parts might require lubrication. See chapter 5 for more details on lubricating fax machines. Be sure to clean all the optical components and the printhead prior to use.

After cleaning test

When you are satisfied that all the moisture has been removed and that the machine has been properly lubricated and cleaned, perform a leakage current test (as explained earlier in this chapter). If the leakage test proves negative, plug in the unit and turn it on. Test the fax completely for proper operation. If you find some moisture still present inside the fax, stop testing immediately and allow the machine to dry out more.

Sand, dirt, and dust

The optical components in a fax machine are extremely sensitive to even a small amount of dirt. Portable fax machines that have been used outside in dusty or sandy environments are susceptible to premature failure—especially if they were accidentally dropped in sand or dirt.

Removal of every last speck of sand, dirt, and dust is critical to ensure proper fax operation and to prevent possible damage to the optical components, the printhead, paper transport mechanism, and other critical parts. This procedure is particularly important if the machine is filled with gritty sand. A soft brush can be used to wipe away the bulk of the sand, or if lots of it is inside, use a vacuum cleaner with a brush attachment. The remaining sand, dirt, and dust can be removed from the cabinet, chas-

sis, and interior with a tack cloth, which is designed to wipe away sawdust from woodworking projects. Tack cloths are available at any hardware store.

Even though the visible dirt and sand might be gone, an accumulation of micro-sized particles of dust might still exist. You can clean the entire inside of the fax machine by liberally squirting it with your trusty can of cleaner/degreaser. The fluid in this cleaner quickly evaporates and leaves no residue. The cleaner/degreaser is a solvent, but it is not petroleum based, so it should not harm metal, plastic, or rubber parts (however, read all warnings on the can prior to use).

Sand and dirt have a way of getting into the most unusual places, so several hours might be required to displace it all. Be sure to inspect the phone line connections on the machine. The grit inside will prevent proper electrical contact, and you might not be able to connect with other fax machines. You can clean the jacks with a swab soaked in alcohol (see FIG. 6-3). Clean both the inside and outside.

As mentioned before, you might need to oil and lubricate the spinning and sliding parts in the machine after cleaning. Follow the directions that are outlined in chapters 4 and 5 and be sure to go lightly on the oil and grease.

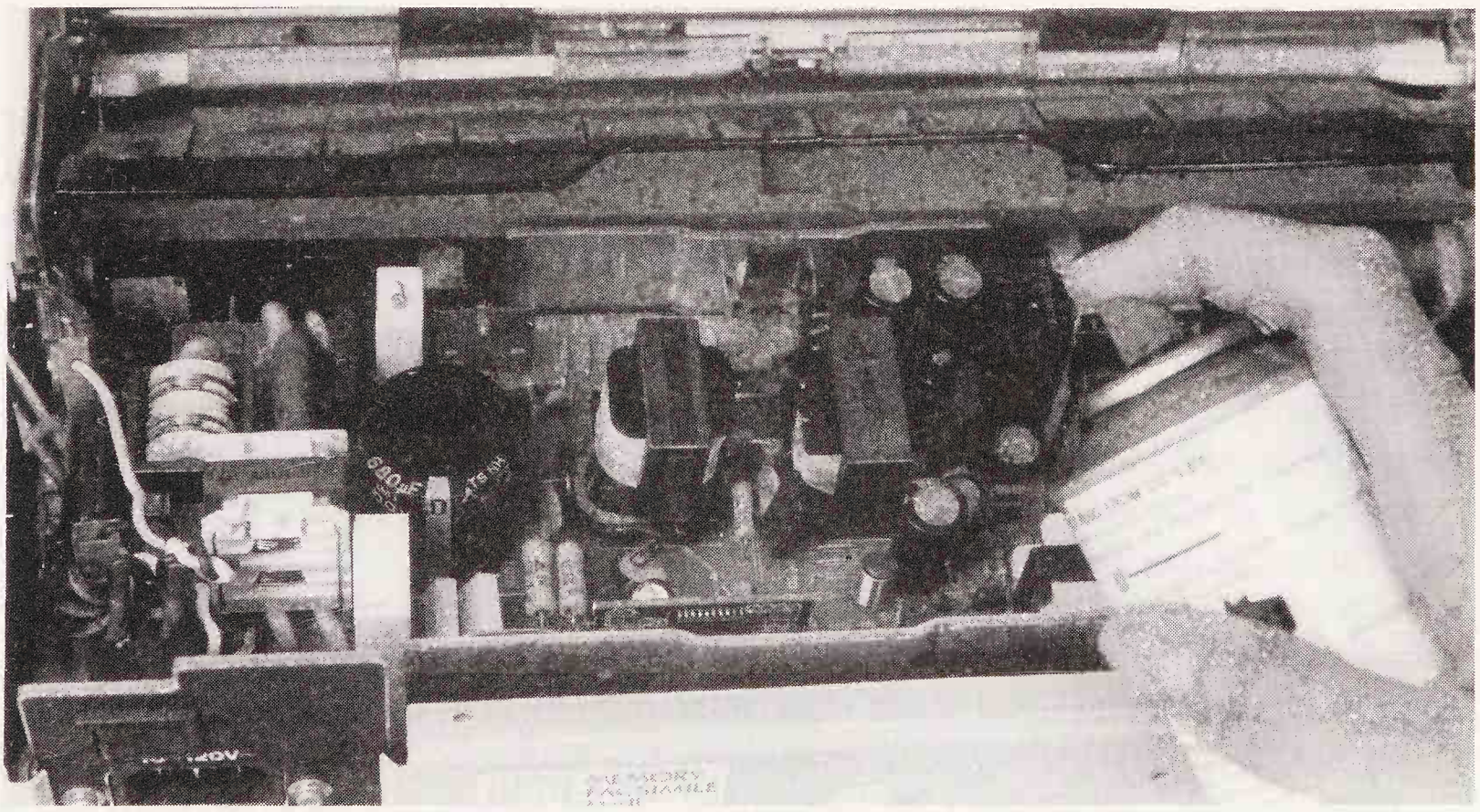


Fig. 6-3. Clean electrical connectors with contact cleaner only.

Foreign objects

Just about any service technician of fax equipment will tell you that a good portion of machine repairs are caused by people inserting "foreign objects" into the mechanism. Horror stories of this sort abound and most are innocent mistakes.

How about the one where a five-year-old boy stuck a peanut butter sandwich into the fax because he wanted to send the sandwich to a friend? Or the forgetful executive who always left staples and paper clips attached to the sheets that were fed into the fax? When these metal objects didn't jam the automatic document feeder, they fell inside

the machine and accumulated at the bottom. After a time, quite a collection of staples and paper clips existed inside the fax.

This kind of accident is best avoided by carefully using the fax machine, and instructing others on its proper use (especially important if you use your fax at home; make it a point to warn the children that a fax machine is not a toy).

Despite the best efforts, instructions, warnings, and rules, foreign objects might still get lodged inside the machine. Some might even be your fault. When this happens, immediately turn off the fax and unplug it. If the object cannot be completely retrieved, disassemble the fax and remove the object.

You might be able to remove the object without complete disassembly. Open the clam-shell cabinet of the fax and attempt to fish out the object. Never use a metal or sharp object to dislodge a foreign object that is stuck in the fax machine. You might also be able to remove objects by opening the fluorescent lamp compartment at the bottom or back of the fax.

Sandwiches, cookies, candy, and other objects often leave their mark—even after you have removed them. You can use a brush or vacuum to remove the crumbs. Heavier or stickier sediments will require removal with a squirt from the cleaner/degreaser.

Leaking batteries

Both portable and office fax machines use batteries. Portable faxes use batteries for power; office fax machines use batteries for storing speed dial numbers, transaction journals, and other information. Given the right set of circumstances, even the best-made battery can leak. The acid from batteries oozes everywhere. It not only blocks electric current, which causes failure, but it also corrodes the inside of the battery compartment and the battery terminals.

If your fax is portable, your best defense against leaking batteries is to remove them if your machine is not used for a long time. Batteries tend to leak the most when they run out of electrical juice, so a battery that sits unused in a portable fax has a very good chance of leaking.

If storing batteries (new or used), keep them in a cool, dry place. You can greatly prolong the shelf life of batteries by storing them in the refrigerator (not freezer). Again, batteries can leak just about everywhere for any reason, so to prevent contaminating your food with battery acid, wrap them in a sealed food storage bag.

Batteries used for memory backup (speed dial numbers, journals, etc.) cannot be easily removed. These can be safely left in place if you're going to put the fax machine in storage for any length of time, However, you should turn the battery switch to OFF, which will disconnect the battery to the backup circuits. This procedure will cause you to lose whatever information was previously placed in the fax's memory, such as regular phone numbers and transmission reports. However, it also prevents the battery from depleting, which limits the chances of battery leakage.

Removing battery acid

Should the batteries leak in your fax machine, remove them immediately and throw them away. Avoid excessive contact with the battery acid because it can burn skin. Use

a lightly dampened cloth to remove the excess battery acid deposits from the battery compartment. If the batteries leaked only a little bit, there might not be any deposits in the compartment or on the terminals. If the terminals look clean and bright, install a new set of batteries and test the unit.

If excessive battery-acid deposits exist, clean the entire compartment with isopropyl alcohol or with a can of cleaner/degreaser. Use a cotton swab to scrub the cleaner on the terminals. You can remove any remaining battery acid deposits by rubbing the surface of the contacts with a pencil eraser.

7

Correcting common fax problems

If you suspect that any part of your fax machine isn't working properly, follow the simple steps that are outlined in this chapter before tearing it apart. In most cases, the problem might not be a malfunction at all. Quite often, the nasty culprit will be a faulty phone cord, a misbehaving phone line, or bad recording paper.

Start at the phone line

Although this step might be obvious, it's worth reiterating because of the time and effort it can save you: before you suspect any problem with your fax machine, check the phone line first. A fax that doesn't receive or send documents might be in perfect health; it might simply not be plugged into the phone line.

Check for dial tone

First, check for dial tone. If your fax has a built-in phone handset, lift and listen for the dial tone. Most fax machines don't have to be turned on or even plugged into the electrical outlet to use the handset. If you hear a dial tone, you at least know that the fax line of communication is still intact.

If you don't hear the dial tone, it might indicate that:

- The fax has become unplugged from the phone outlet.
- The line (cord) between fax and outlet is faulty.
- The outlet is faulty.
- The wiring in your office or home is faulty (you have a shorted or open circuit).
- A problem exists at the telephone company.

Take a closer look at each possible fault.

The fax is unplugged

Check the phone line between the fax machine and the phone outlet. Be sure that the modular plug on both ends is securely inserted into the jacks.

Cord between fax and outlet faulty

You can quickly test the outlet and rule out the line by plugging in a good phone (this phone works because you recently tested it on another outlet in your office or home). Plug in the phone and listen for a dial tone. No dial tone indicates a further problem; presence of the dial tone probably means that the line between the fax and outlet is faulty and should be replaced.

Faults in phone cords can be permanent or intermittent. Permanent problems are easiest to catch because the fault is continuous. Intermittent faults come and go, depending on the circumstances. For example, one of the wires in the cord could be broken. The insulation of the cord might keep the severed wires in close contact, depending on the position of the cord. Bend the cord another way and suddenly the contact is broken—your fax machine loses contact with the outside world.

The moral: When checking phone cords, manually twist and loop them in an attempt to uncover any such intermittent problem. You should also jiggle the plugs in their jacks to uncover intermittent problems there, as well. The contact between jack and plug connections might be tenuous. Under some circumstances (heat, humidity, temperature, phase of the moon, you name it), electrical contact might be lost.

Faulty outlet

The best test for a faulty outlet is to use the "known, good" phone instrument, described previously. If you don't have an extra phone, you can use a telephone line tester (such a tester is detailed in chapter 3).

Both the good phone and the phone tester require a modular jack. This isn't always possible, such as when you test junction boxes inside or outside of your home or office. For these, use a simple speaker tester (FIG. 7-1). Connect the speaker across the phone

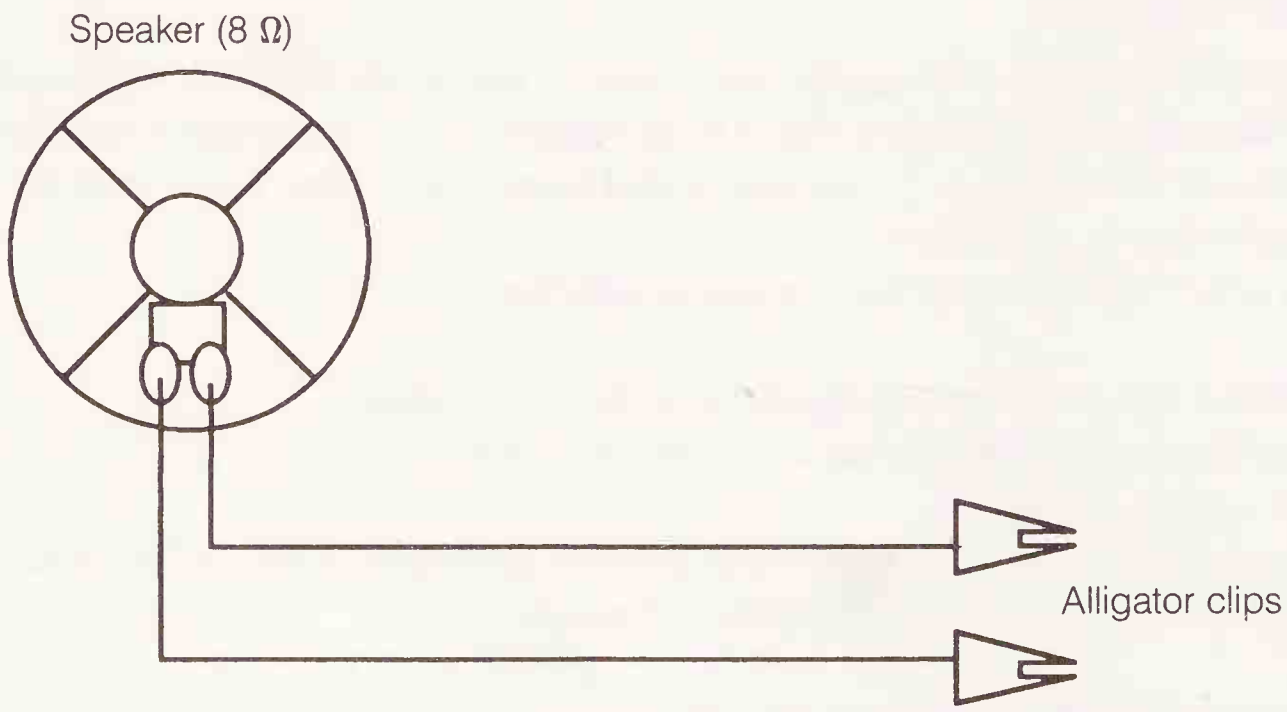


Fig. 7-1. You can rig your own simple telephone line tester using a speaker, some wire, and two alligator clips.

lines as shown and listen for the dial tone. Use a standard 8-ohm transistor radio speaker. You can find these speakers at most electronic stores. The cost is minimal, only about $2. The ends are alligator clips, which can also be found at most any electronic store.

The speaker only tests for dial tone, not for complete phone line operation. If you want a more complete testing apparatus, but still need to access junction boxes with no modular jacks, make a line tap, like the one in FIG. 7-2 (junction boxes connect phone wires together; every home or office has at least one junction box, where the phone companys' wiring meets yours).

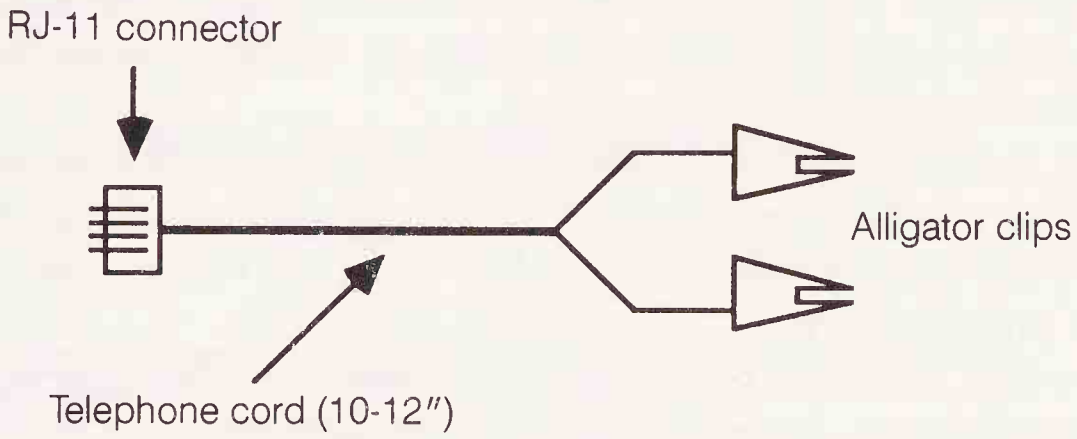


Fig. 7-2. A homemade telephone line tap.

The line tap consists of a short end of phone cord. Solder (or crimp) alligator clips to the ends and you're in business. To use the line tap, just connect the colored leads to the proper terminal in the junction box.

The low impedance of the speaker will make the phone circuits "think" that you've just lifted the handset on a real telephone and the dial tone should sound. If no dial tone exists, try reversing the leads and try again. Still no dial tone? It might indicate a problem in the outlet. Disassemble the outlet, if necessary, and inspect it. Are any of the wires loose or touching? Be on the lookout for:

- Open circuit. Wires that should touch don't. Typically, one of the wires in the phone line will have worked loose from its connecting terminal. Reattach it.
- Short circuit. Wires that shouldn't touch do. Occasionally you might find that two adjacent wires have come in contact, rendering the phone line useless.

Some open and short circuits aren't always easy to spot, at least not visually. The wires might not short until you push the outlet back into its hole in the wall. The pressure of the wires against the outlet might cause wires to touch. For this reason, it's very important to make the outlet connections clean and precise. Avoid cutting more insulation from the wire than is really necessary (1/4- to 1/2-inch should suffice). If lots of extra wire sticks through the wall, cut the extra off. You don't need it.

Intermittent open circuits can be caused in the same way. If the outlet is on an outside wall or if it is otherwise exposed to the weather, the copper conductors that are used in the wire could corrode over time. Corrosion reduces the electrical contact. In time, it's possible for the corrosion to inhibit all electrical conductivity. If the conductors look dull

and dark brown (instead of the normal bright copper look), cut the wire back an inch or two, and restrip the ends.

Faulty wiring

Most offices and homes have more than one outlet. An open or short circuit can occur at any of the outlets, and still cause the problem of no dial tone. If possible, locate the phone junction box.

Don't worry: The junction box belongs to you. You can make whatever repairs you need at the junction box, as long as you stay on "your" side of the high-voltage/lightning discharge protector (this device often looks like a domino). The wires on the other side of the protector belong to the phone company, and you should never apply any device or test instrument to it.

Many office buildings use multiterminal outlet boxes to service the many telephone lines. You might or might not be able to access this. In any case, if the building doesn't belong to you, you'll need permission to work in the outlet box, or else call in a technician to find the problem for you.

If you can access the phone outlet, use your 8-ohm speaker to test for a dial tone. If you can hear the dial tone, the problem lies somewhere between the box and the fax outlet; it might not affect other outlets. If you can't hear it, the fault is affecting all outlets. To determine if the problem is inside your home or office, disconnect one of the wires at the junction box. This action disconnects one leg of the phone line from the circuit, and it counters any symptom that is caused by a short circuit in the wiring. Only use an insulated nut driver or pliers; you could receive a shock otherwise.

Connect the 8-ohm speaker to the terminals in the junction box. No dial tone means the problem is with the phone company. A dial tone means that the fault is somewhere in the wiring in your home or office.

If you have a volt-ohm meter, dial it to dc volts, range 50 volts or more. Touch the probes to the terminals in the junction box. Your meter should read about 48 volts. No reading means that the phone line coming to your house is dead.

Assuming the line is okay, the problem is therefore somewhere in your wiring. Reattach the wire that you previously disconnected from the terminal. Again, use only an insulated nut driver or pliers. Close the junction box.

Phone outlets can be installed in a home or office—either in parallel or in series. Sometimes, it can even be both. A short anywhere in the system will affect both wiring configurations the same: all outlets will be dead. However, an open circuit behaves differently, depending on how the outlets are wired:

- Outlets in series (FIG. 7-3) are attached one right after the other in daisy-chain fashion. A break *anywhere* along the line will affect all outlets after it.
- Outlets in parallel (FIG. 7-4) are connected by separate lengths of wires to the junction box (this box can be the one that connects your line to the telephone company's or it can be some internal distribution box inside your home or office). A break that leads to one outlet will not affect the others.

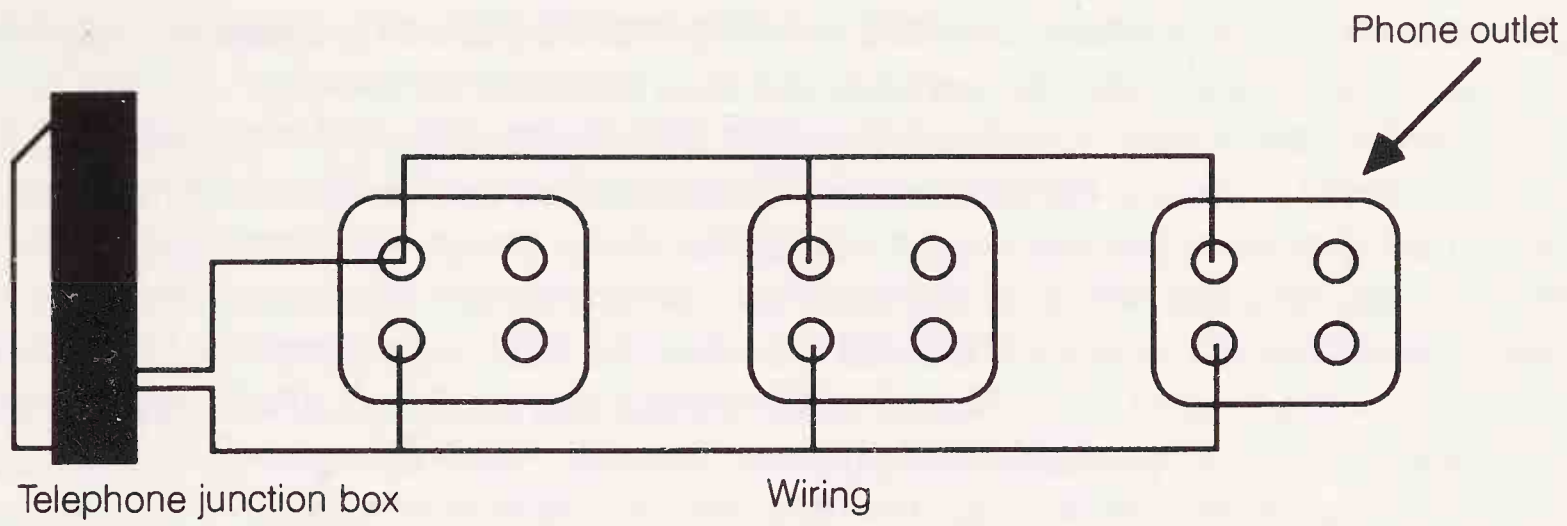


Fig. 7-3. Phone extension outlets wired in series.

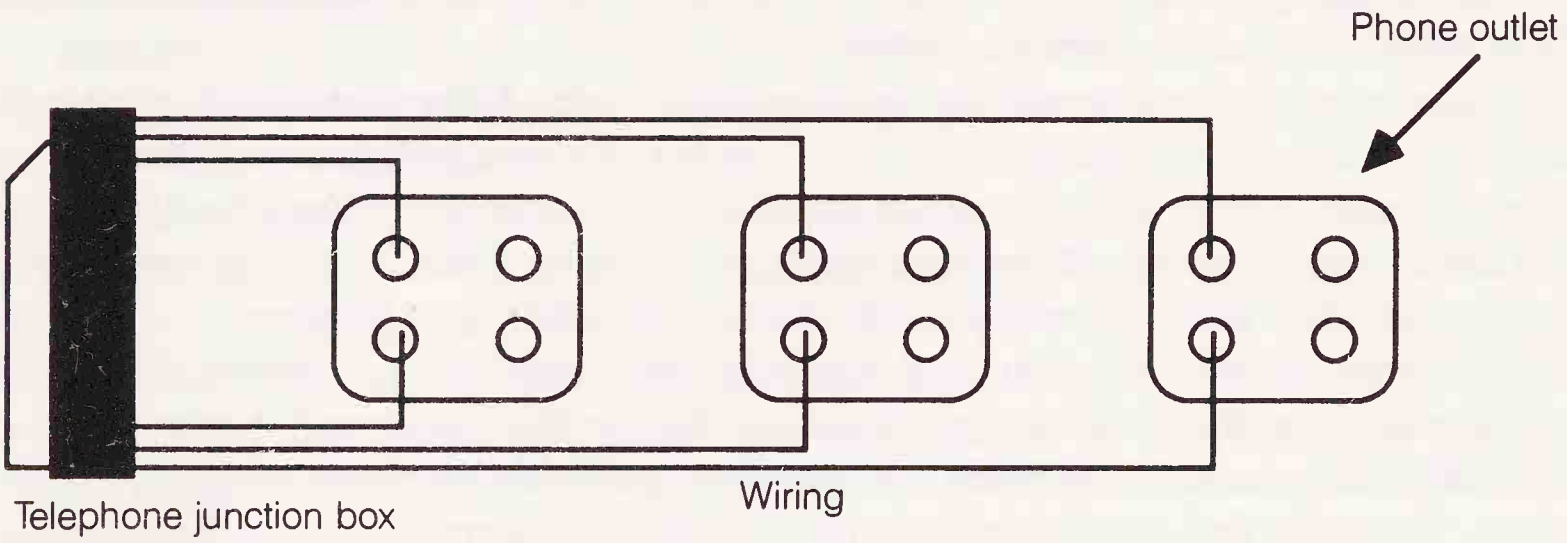


Fig. 7-4. Phone extension outlets wired in parallel.

For economy, most homes use the series method. This method requires that you locate all the phone outlets and test each one. Visually test for open or short circuits. If necessary, examine the outlets with your good telephone or use the 8-ohm speaker to test for the dial tone. Chances are, sooner or later, you'll find the offending outlet and correct the problem.

No amount of sleuthing can uncover all the wiring problems that might occur. Call in help if you can't locate the problem in your phone lines. Professional phone installers use special tools and techniques to isolate problems in inside wiring. The cost for this service can be anywhere between $50 and $100, but in most cases, the fault can be found within a half-hour. You then have the option of having the service tech repair the problem (therefore adding to your bill), or electing to do the work yourself.

Problem at telephone company

Loss of phone service happens to everyone at one time or another. In urban areas, it is not uncommon for phone company equipment to fail during peak-use hours, typically

between 8:00 and 10:00 A.M., and 3:00 and 5:00 P.M. This failure is transitory; after the volume of calls drops after the workday, the lines return to life.

The dial tone means the phone company is ready to take your out-going call. No dial tone could mean the circuits are over burdened, and not enough dial tone is available. This problem must be worked out at the phone company. Often, dial tone will return if you keep the phone off the hook for a minute or two. Unfortunately, most fax machines will report an error if the dial tone can't be detected within 10 – 20 seconds. One way to circumvent this problem is to lift the handset on the fax (if so equipped) and listen for the dial tone yourself. Once you hear the tone, "ask" the machine to start dialing. When dialing is complete, gently replace the handset in its cradle.

Noisy phone lines

Just because you hear a dial tone, the line isn't necessarily acceptable for fax communications. Excessive noise and other line impairments can prevent your fax from successfully transmitting or receiving a document.

Line noise is a far more difficult problem to uncover. A line that sounds good to you might be riddled with impairments, which hinder efficient fax communications. However, you can perform a simple test to listen to audible line noise. You'll be able to hear the severe line noise that plagues fax machines the most. Other line impairments, such as echo and dips (as detailed in chapter 2) are more difficult to interpret.

To listen to line noise, you need a good phone, preferably a high-quality one. Lift the handset from the cradle and press a single digit on the dialing pad. If present, you'll be able to hear noise in the local line, between you and the phone company's equipment. You might find that line noise is heavier during a storm. Moisture, lightning, and wind can disrupt phone lines and cause excess line impairments.

The phone connection can receive line noise most anywhere along the way. To complete the test, dial the number of the remote fax and listen for static, echo, and other audible forms of line gremlins.

If you suspect noise and other impairments in the local line, you can contact the phone company and ask them to test it for you. The test is not necessarily immediate or free. Get the details first.

Dead parameter-setting battery

Most all fax machines use a small battery to power the memory circuits that hold the parameter settings. These settings include the current time and date, the ID of the fax, transmission and reception journals, operating modes (such as standard or fine resolution), phone numbers, and more. If this battery goes dead, you will lose everything in the memory. You'll need to replace the battery and reprogram the fax.

Most fax machines will warn you when the battery is weakening and needs to be replaced. Don't ignore this warning. Follow the instructions that accompany the fax and replace the battery as soon as you can. Usually, you have a few minutes to remove the old battery and replace it with a new one. A capacitor in the fax machine retains enough charge to operate the memory circuits until you can insert a new battery. In

other fax machines, you need to keep the unit plugged in (and sometimes turned on) while you are replacing the battery.

The battery might also leak, which kills it and causes a mess in the battery compartment. Chapter 6 addresses the topic of leaking batteries.

After battery replacement, always check the memory. Many fax machines let you print out the current settings. One such sample printout is shown in FIG. 7-5. The contents of the printout vary between models, but it usually contains the current time and date, ID, speed dial numbers, and operating settings.

If your fax doesn't provide this test sheet, review the current settings by cycling through the parameters and watching the results on the LCD panel. It is necessary to reprogram the fax afterward.

Fax controls and parameter settings

Most mid- and high-end fax machines have many programmable "bells and whistles." The parameters for these special features are set by way of the front panel buttons. If your fax is misbehaving, check the controls and parameter settings, or reinitialize the fax with brand new settings.

You'll need to refer to the manual that came with your fax for the exact instructions, which vary from model to model. Fax machines used in office environments are more apt to be misprogrammed by persons who don't know what they are doing. Incorrect parameter settings can cause your fax to freeze and apparently reject any commands from the front panel. In fact, the fax might be in delay broadcast (timer) mode and is waiting for the time to roll around so it can transmit the documents that are stored in its memory.

Check for the following:

- Correct time and date. Some fax machines won't operate if the time and date settings are wrong. This problem occurs when the internal battery goes dead, or when someone messes with the parameter settings.
- Mode settings, which include resolution, gray scale, memory, broadcast, etc. For example, if the fax is in delayed broadcast mode and it has an internal document memory, it will scan your pages but not dial the phone. In this mode, it is expecting you to provide a time of day to place the call.
- Incorrect speed dial number. Speed dial numbers can get jumbled if the battery dies or weakens. Or someone else in your office might inadvertently erase or overwrite one of your speed dial numbers. Never assume that the speed dial number is correct. Verify it by looking at the LCD panel on the fax machine as the number is dialed.

Be sure to learn the front panel controls. If your fax is in an office environment, post clear instructions on how to use the machine. Instructions help reduce operational problems. Many companies prefer to limit fax use to just a few trained persons. Consider this approach in your office if you think it is necessary.

UF-260 ******* -FAX PARAMETERS- ******* DATE MAR-19-1991 ***** TIME 05:35

PARAMETER NUMBER	CURRENT SETTING	STANDARD SETTING
01	1	1
02	1	1
03	2	2
04	1	1
05	1	1
06	1	1
07	1	1
08	1	1
09	1	1
10	-	-
11	1	1
12	1	1
13	-	-
14	-	-
15	2	2
16	2	2
17	2	2
18	1	1
19	1	1
20	1	1
21	1	1
22	1	1
23	-	-
24	-	-

Fig. 7-5. A sample of a fax parameter report.

At the very least, be sure to note the regular settings of the front panel controls. If they have been changed, refer to them to get the fax machine back in working order.

Paper problems

Apart from telephone line troubles, the most common problems besetting fax machines are caused by recording paper complications. Paper can jam or tear inside the mechanism. Many faxes have an indicator (light or LCD message) to warn you of the paper problem, but not all do. Check visually for any problems, re-adjust the paper, and try again.

Thermal fax paper is also sensitive to light, moisture, and heat. Any and all three can have an adverse effect on your printouts.

- Gray or discolored paper might have been exposed to excessive heat and/or light. Try removing some of the paper on the roll; the discoloration might be limited to just the first few layers.
- Uneven printing is often caused by moisture. Check the paper for a damp feel. If it seems cold or damp, let it dry for a few days. Keep the paper in a dark, cool place. Paper that has become wet (you spilled water on it, for example) might be beyond salvage. Throw it away and try a new roll.
- Thermal fax paper has a natural curl because it is wound tightly around a plastic or cardboard core. Sometimes the paper curl can become excessive and cause the paper to jam in the machine. These problems occur when the roll is almost depleted and the curl is very tight as a result of the diameter of the paper core. Toss the remainder and use a new roll. Curl can also be a problem if the paper has been subjected to excess moisture. Let the paper dry for a few days and try again.
- Streaks, blotches, and other defects can indicate an internal problem in the fax, or simply that the paper is old. Thermal fax paper has a shelf life of about one year when it is properly stored. Paper that is old, or subjected to heat, moisture, and sunlight, can yield poor results.

If the paper comes out absolutely blank, it might be installed upside down (the paper must be inserted in the machine so that the coated, heat-sensitive side faces the print element). It might also indicate an internal problem. Internal problems are covered more fully in the next chapter.

Troubleshooting checklist

To recap, before you tear open your fax machine:

- Check for dial tone.
- Inspect the phone cord.

- Inspect the outlet.
- Test for line noise.
- Check the condition of the parameter-setting battery.
- Refer to the front panel controls and parameter settings.
- Check for paper problems: jams and tears, as well as damage caused by heat, light, and moisture.

8

Troubleshooting fax malfunctions

Troubleshooting literally means aiming at trouble and firing away until you hit the bullseye. In a more practical sense, *troubleshooting* means locating and eliminating sources of problems in a logical and predescribed manner.

Troubleshooting is the basis of electronic and mechanical repair, and a thorough grasp of its techniques and procedures is important. Just as you can't hope to shoot at a target with a blindfold around your head, you cannot wildly attack a problem in your fax and pray that you luck onto the solution. Troubleshooting lets you approach the problem from all angles and zero in on the cause, with the least amount of wasted time, energy (and most of all), money.

This chapter details the concepts behind fax troubleshooting techniques and applying them to actual hands-on procedures. It also details a number of specific mechanical and electronic maintenance and repair points for fax machines. These specifics consist of troubleshooting flowcharts that you can use to pinpoint common fax problems.

The essence of troubleshooting

You can better understand the role that troubleshooting plays in the repair of fax ailments by using a more familiar concept: family car problems. Let's say you go out to your car one morning, turn the key, and the car won't start. The battery turns the engine, but even after 10 or 15 tries, the car simply won't start. Every minute that you spend cranking the engine makes you one minute later for work.

You could open the hood, tear out the engine, and rebuild it, or you could replace random parts, thinking that it's one of them that's causing the problem. You know better, of course, and you stop to think: why won't the car start? The engine turns over, so you can rule out a bad battery. But the problem could be in the ignition system, the fuel

lines, or a number of other subsystems. In fact, several possible causes could exist:

1. The engine is flooded.
2. The spark plugs are fouled.
3. The engine isn't getting gas.
4. The engine timing is off.
5. The spark isn't strong enough.
6. The plugs aren't sparking.
7. The engine isn't getting enough air because the choke is closed.

And so forth. Once you have identified the possible causes, you can take corrective steps on a one-by-one basis. You would start with the most common or probable cause, then work your way down. In most cases, failure to start the engine is caused by flooding. To remedy this, you would open the hood and remove the aid filter and perhaps a couple of spark plugs. The gas evaporates and you would try to start your car. If the problem still persists, you would go to step two, and so forth.

The basic three-step process to troubleshooting applies to faxes just as it does to hard-starting cars:

Step 1: Analyze the symptom ("car won't start but engine turns over") and develop a list of possible causes.

Step 2: Arrange the causes in order, from the most likely to the least likely.

Step 3: Start at the top of the list (most likely cause), and by a process of elimination, inspect, test, or otherwise rule out each possibility until the problem is located.

Once the problem has been found, clean or repair the faulty component.

Troubleshooting flowcharts

It's sometimes easier to visualize the troubleshooting process by using flowcharts. *Flowcharts* are graphic representations of the possible causes and their solutions. The exact form of the flowchart can vary, but the basic information they contain is the same.

One example of a troubleshooting flowchart is shown in FIG. 8-1. The chart is labeled with the problem (or symptom), which in this case is, "engine turns over but won't start." Below the title is a set of vertically stacked boxes. Each box on the left-hand side contains a possible cause for the malfunction, usually a bad or dirty part or subsystem. The boxes are organized from the most likely to the least likely so that you won't waste your time with an unusual fault when the actual cause is really quite common.

Each level holds two or three boxes. These boxes contain the suggested remedy, and in some cases, the procedure for testing the suspected part or subsystem.

Arrows connect the boxes so that by thinking of the boxes as questions, you can answer them simply with a *yes* or *no* response and navigate yourself around the chart. Each *no* answer to a possible cause drops you to the next level. A *yes* answer moves you laterally as you make tests and repairs.

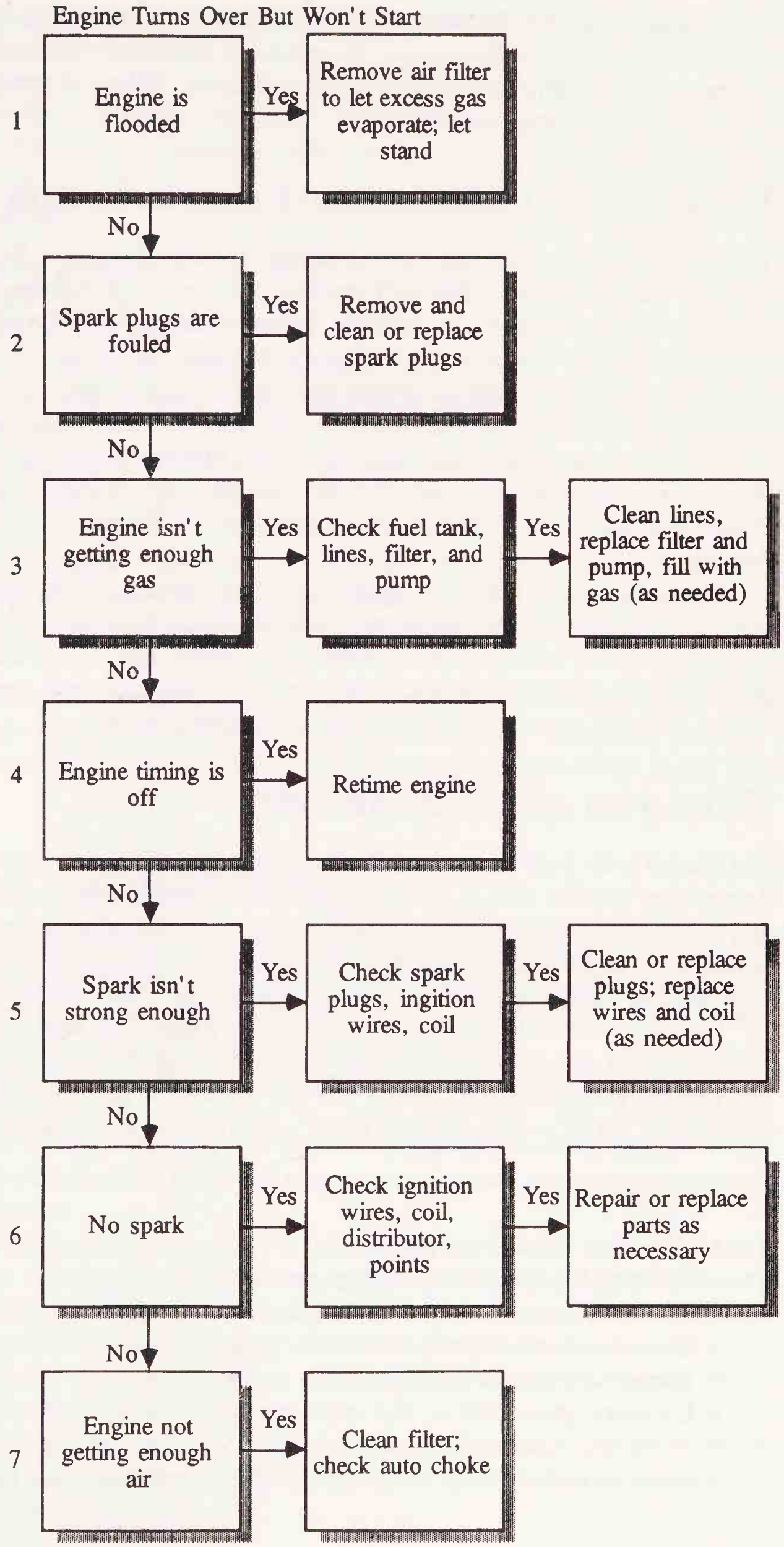


Fig. 8-1. Engine trouble-shooting chart.

In actual practice, however, you don't really know where the problem originates until you test each possible cause. Therefore, at each level you initially answer with a *yes* response, until you have the opportunity to test it. If the test proves negative (not the cause), you drop to the next level.

Using the troubleshooting charts in this chapter

The troubleshooting flowcharts in Appendix D follow the same form and logic as the previous example. If your fax isn't working properly, find the chart that most closely matches the symptoms of the machine. Some machines exhibit multiple symptoms, so you might need to consult several charts to pinpoint the cause.

Once you've identified the proper chart to use, start at the top level, and work your way down. Eliminate the causes that you're sure are not the source of the problem. Doublecheck your work, make sure you haven't missed something, and don't forget the obvious. By far, most problems with fax machines are caused by seemingly innocent things, like bad paper, incorrect function settings, a dirty switch, or paper debris inside the unit.

Whatever you do, avoid the temptation to tear your fax apart before you adequately identify the cause. Disassembly and removal of any part, even the top cover, should only be done after you've eliminated the other causes. Remember that some of the components in fax machines cannot be repaired or replaced without special tools and techniques, so don't remove any parts unless you absolutely have to.

What you can and can't fix

You can try to fix anything in your fax machine. It's yours, you own it, and you're free to do anything you like with it. Many problems are easily handled by the home technician, and there is no reason why you should not diagnose and repair them yourself. However, a number of malfunctions are best left to a repair technician who has access to the service literature and special alignment and test jigs for your machine.

Here is a general list of the components and assemblies that you can fix in your fax and those that should be referred to a qualified technician. This list is not absolute by any means. Your level of expertise and the amount of service material and tools you have or can obtain greatly influence the types of repairs you can perform.

What you can do:

- Clean and inspect the printhead.
- Clean and inspect the scanning optics.
- Clean the exterior and interior to remove dust, nicotine, and other contaminants.
- Clean and replace belts and rubber rollers.
- Inspect and replace springs.
- Lubricate gears, shafts, and other moving parts to prevent them from grinding.
- Replace or resolder broken wires.
- Clean or replace dirty or broken switches, including front panel switches.

- Replace the main printed circuit board (PCB) and ancillary boards (special handling of the boards required).
- Replace common electronic components (resistors, capacitors, diodes) on the printed circuit boards (PCBs), but *only* if original value is known, and when you are skilled in the art and science of soldering.

What you should not do:

- Disassemble the paper cutter mechanism.
- Disassemble the optics.
- Replace optics or printhead.
- Adjust any roller, gear, or guide rollers inside the machine.
- Adjust trimmer potentiometers on the main PCB without the use of a schematic and an oscilloscope.
- Replace ICs, transistors, or any other component where an exact replacement or substitute cannot be guaranteed.

Fax machines are complex electronic and mechanical devices. Their reliance on special proprietary ICs and zero-tolerance mechanical alignments leaves the average consumer or electronics hobbyist with reduced opportunities for complete home/office repair.

However, doctoring the ills that beset the average fax is not entirely out of your hands. On the contrary, the new modularity of fax design makes mechanical and electronic faults very rare—assuming that the machine was well manufactured in the first place.

What to do if you can't fix it

Should you find that repairing your fax is beyond your technical expertise and resources, don't fret. Make a note of the problem and the suspected cause, reassemble the machine, and take it to be serviced. By performing the basic troubleshooting procedures yourself, you make the repair tech's job that much easier.

The labor charge might not be reduced, but the problem might be fixed properly the first time around—with no costs added for "additional work" that the technician found was necessary after the machine was opened. A fax that must be returned to the service shop several times is often the result of a communications problem between you and the repair technician.

Some repair techs and service centers frown on consumers who repair their own fax machines. If you've followed the directions in this book and in the manufacturer's literature, and used the right tools and cleaning supplies, you've done nothing that the service shop would not have done—and they would have charged you handsomely in the process. When performed properly, routine maintenance and troubleshooting procedures do not harm the fax.

Avoid a repair shop that adds an additional service fee simply because you've opened the top cover and made some preliminary tests. Unless you have further dam-

aged the machine, the extra service fee is completely unnecessary and very unethical. After all, an automotive garage would not add $50 to their price of a tune-up because you changed the oil 1,000 miles ago.

If you are sure that the fault lies in a component that cannot be repaired and replacement does not require critical adjustment, contact the manufacturer and ask for a parts list (if you don't already have it). Identify the faulty component and order a replacement. Most manufacturers that sell replacement parts to the public ask for payment in advance, and the easiest way to do it is by credit card. Few will ship COD.

Let's say the manufacturer is uncooperative, what then? Try to obtain the part from a repair center that is authorized to work on your brand of machine (in this case, "authorized" simply means that the repair center has an open channel for replacement parts, though it can also mean that the repair center has been specifically trained to work on your brand). The shop might tack on a small service fee, which is understandable.

Receiving the replacement parts from the manufacturer or a repair center might take as little as a week or as long as several months, depending on its point of origin. Keep records of when you ordered the part, and if you've written any follow-up letters or phoned the manufacturer directly. Ask for the names of everyone you speak with and write them down. You never know when this additional information will come in handy.

Service politics

Of course, ordinary mechanical and electronic breakdowns do occur. You can repair a number of these breakdowns yourself. Most dysfunctions can be corrected by cleaning dirty electronic contacts and switches, oiling or greasing the moving parts, repairing the occasional broken or frayed wires, and replacing worn parts, such as rollers, belts, and plastic gears.

Unless you have specific training and experience in working with both high-speed digital and analog circuits, and have the proper servicing tools, problems with the optics, ICs, and other components on the circuit boards should be referred to a repair technician.

More complex problems require a schematic or service manual, an oscilloscope, and a variety of specially-made alignment and test jigs. These problems also require additional troubleshooting and repair techniques, which are beyond the scope of this book. If you are interested in learning more on this subject, see Appendix B for a selected list of general and specific electronic troubleshooting and repair guides.

Many manufacturers will sell you a copy of the schematic or service manual, but be prepared to spend up to $30 for it. The wait can take up to eight weeks, so order the manual *before* your fax breaks down. The names and addresses of most fax manufacturers are provided in Appendix A. If you don't see the manufacturer of your machine listed, or if the manufacturer has moved, refer to the owner's manual or to the warranty card. It should list the main address of the manufacturer, plus local and regional repair centers.

Most fax machine manufacturers will not sell the test jigs and alignment tools directly to consumers. In fact, many fax manufacturers won't even sell the tools to independent service centers! Other than routine cleaning and checkout, along with replace-

ment of some mechanical parts (most or all of which you can do yourself), all but "authorized" service centers are directed to send defective units back to the manufacturer for repair.

One general exception to this rule is when defects occur in the main printed circuit board (PCB), as well as in the modular sections for the power supply and front panel controls. These problems can often be handled in the repair shop, but they almost always entail completely exchanging the old board for a new one. In the service trade, a technician who repairs electronic products simply by exchanging a PCB is euphemistically called a "board swapper." These technicians don't like it (the implications in the phrase as well as the inability to get parts), but individual components and ICs are not always available from the manufacturer; the technicians must take what they can get.

If you suspect a problem with the PCB in your machine, you might be able to get a replacement directly from the manufacturer and change the board yourself. This could save you $75 or more in labor costs. Fax makers sell the boards on an exchange basis. You send in the old defective board, along with a check or money order to cover the service fee, and they send you a tested board in return. Although the replacement cost for a board varies, it is typically in the $75 to $125 range.

Troubleshooting techniques

Effective troubleshooting depends mostly on common sense, but here are some tips you'll want to remember:

Write notes

Write copious notes. Write everything down, including how you removed the top cover, the volt-ohm meter readings, visual observations, parts you replaced—anything and everything. By keeping notes, you will not only be able to retrace your steps if you get hung up on a particular fault, but you'll be able to better deal with recurring problems. The maintenance log in chapter 9 provides blanks for notes; use additional sheets of blank paper, if necessary.

Use the proper tools

Refer to chapter 4 for more information on the proper tools to maintain and service your fax machine. Don't "make do" with a tool that was not designed for the job. If you don't have the required tools and supplies already, spend a little extra on them. The maintenance and troubleshooting procedures outlined in this book require only the most basic hand tools and test equipment. Expensive items (oscilloscopes, function generators, and frequency counters) are not absolutely required, unless you opt to try more detailed troubleshooting.

Use your volt-ohm meter correctly

A number of troubleshooting procedures require you to test the suspected component or assembly with a volt-ohm meter. Use this piece of equipment correctly or you might miss a potential fault or replace good components.

To test continuity, select the resistance function on the meter. If the meter is not auto-ranging, choose an initially high-resistance range—on the order of 10,000 ohms or more. Attach the two meter leads (or probes) to either side of the switch, wire circuit, or connector that you are testing, such as that shown in FIGS. 8-2 and 8-3. Double-pole double-throw switches, sometimes used in power switches, have extra terminals to check.

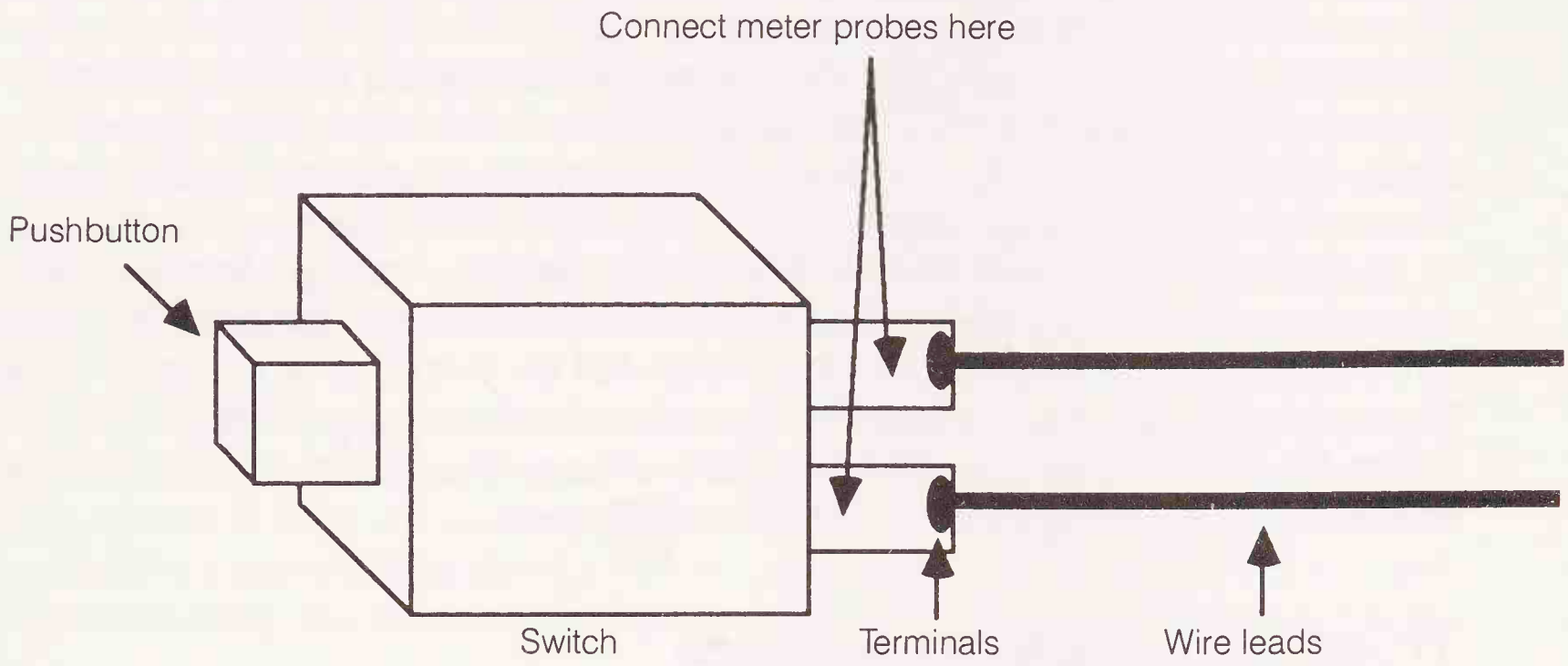


Fig. 8-2. How to test continuity and shorts in a switch.

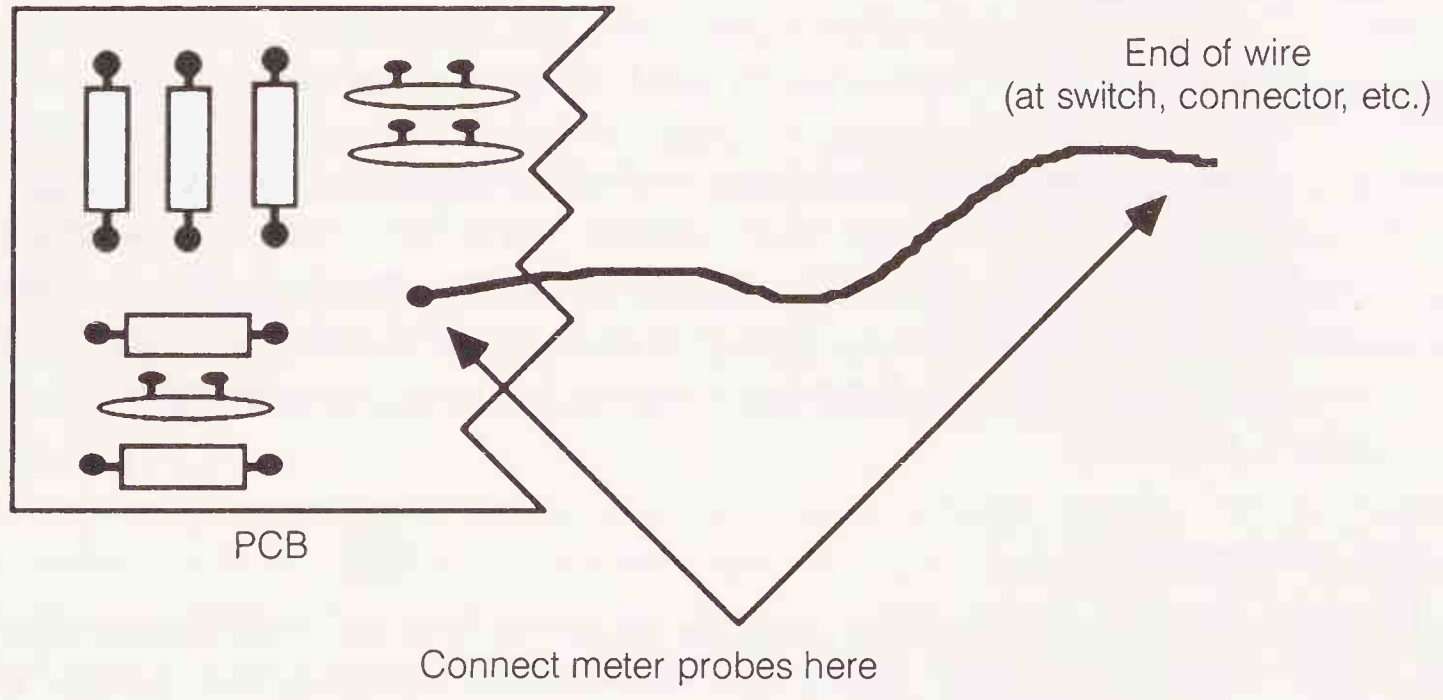


Fig. 8-3. How to test continuity and shorts in wire.

Figure 8-4 shows how to use your meter to test one of these switches.

For the most part, continuity is a "go/no-go" test. You will either get a reading of 0 ohms, which means that the circuit or connection between the two test leads is complete; or infinite ohms, which means that the circuit is either broken or that the connection between the two test leads is open.

Sometimes, a reading of 0 ohms is exactly what you want, i.e., when you are testing the closure of a switch or a length of wire to make sure it is not broken inside. Other times, 0 resistance means that something is shorted out, which is an unhappy situation.

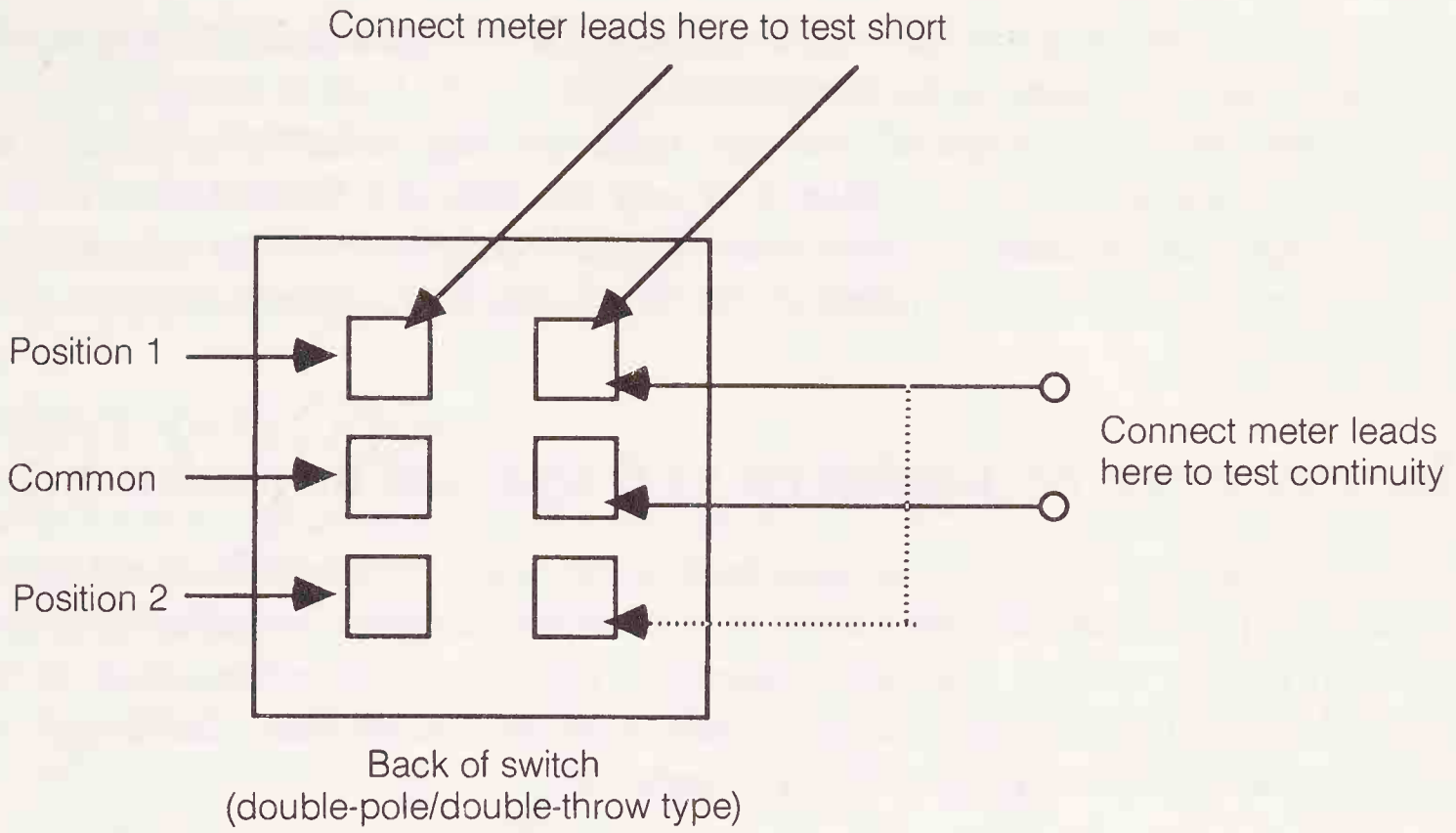


Fig. 8-4. How to test continuity and shorts in a double-pole, double-throw (DPDT) switch.

Likewise, a reading of infinite ohms (which meters display in a variety of ways), might be correct for a given test, 0 ohms for another test. The troubleshooting charts later in this chapter provide more details on the typical readings you should get for any given instance.

When using the meter, do not touch the metal part of the probes. Your body has a natural resistance, however high, and you will add or subtract it to/from the measurement you're trying to take. Always take your readings by grasping the test leads by the plastic insulator.

Volt-ohm meters test more than continuity, of course. For example, you will want to use the ac and dc voltage functions to test for proper voltage levels going into and out of the unit's power supply. Be sure to select the correct function *before* you connect the test leads to the live circuit. With many meters, connecting the leads to a dc voltage when the unit is dialed to ac might burn out a fuse or cause internal damage.

If the meter is not the auto-ranging type, always choose a range that is higher than the input voltage. If you are not sure of the voltage level, choose the highest one first, then work down. Most all digital meters have built-in overload protection to prevent damage by choosing too low a range. However, the needle in an analog meter can be permanently bent or broken if you accidentally choose a range that's too low, and the meter violently swings to the end of the scale.

Going beyond the flowcharts

Few fax machines are designed exactly alike. Differences between brands, even between models of the same brand, require slightly different troubleshooting procedures. Use the flowcharts in Appendix D as a starting point only. The design and construction of your fax might require additional troubleshooting steps. If possible, refer to

the schematic or service manual to your machine. It will often detail testing points or procedures that are unique to the particular model.

In other cases, the design of your fax might not require that you perform some troubleshooting procedure. For instance, if your machine is a flat-bed type, it lacks a paper transport mechanism, so problems with this assembly are of no concern to you. Likewise, machines without a paper cutter won't require maintenance steps that involve the cutter.

Maintenance procedures and special adjustments

Most of the troubleshooting steps described in the charts in Appendix D are standard maintenance procedures that were covered in previous chapters. Specifically, the procedures call out for routine printhead cleaning, replacement or rejuvenation of belts, tires, and other rubber parts, and general cleaning and lubrication. These points are more fully discussed in chapter 5 and in chapter 6.

Using the troubleshooting charts

The remainder of this chapter details common fax problems and their cares. Appendix D is devoted to a series of troubleshooting charts that detail the possible causes and suggested solutions for a series of common and not-so-common fax ailments. The charts are not meant to be definitive, but they should go a long way to help you pinpoint a problem in your machine. See earlier in this chapter on how to use and interpret the charts. Also refer to chapters 4 and 5 on the tools and supplies for fax maintenance and repair, and how to use them.

To prevent overcomplicating the charts, they have been designed to apply specifically to the ac-operated machine. Many of the same problems, causes, and solutions will apply to portable faxes, but troubleshooting techniques differ in certain situations.

You can still use the troubleshooting charts to diagnose most problems in portable units, however, because the basic reasons behind the fault will be similar. For example, a portable fax does not have an ac cord, so you would not test its cord if you are having trouble operating the unit. But you would test the battery or battery charger in a similar manner as you would an ac cord.

Look to the simple things first

In using or looking over the charts, you might find that some of the possible causes seem overly simplistic. The biggest mistake you can make in servicing your fax is overlooking the obvious. I am reminded of the time when, in my younger and more foolish days, a color television set came in for repair. The set would turn on, and I could hear sound, but it had no picture. It was an old tube set and I tore into it with a vengeance, replacing every tube that could possibly cause the problem. Alas, I replaced one tube after the other, with no results.

Then, innocently enough, I began to fiddle with the control knobs. I turned up the

brightness control and the picture magically came on! After spending well over $50 on tubes (and this was in the 1960s, so 50 bucks was a lot more money than it is now) and wasting a whole day trying to fix the set, the problem turned out to be an inadvertently turned down brightness control.

This lesson was expensive, but it was a good one. If something doesn't work, odds are, it's a simple cause with an equally simple solution.

Battery problems

Portable fax machines operate from batteries; and when used with an adapter they use household current. Batteries for portable units are rechargeable, usually the nickel-cadmium (or ni-cad) type, and they are subject to certain difficulties.

- Ni-cad batteries should be fully charged before use or their life-expectancy is reduced. Before using the camcorder or portable, fully recharge the battery for the recommended period of time.
- Ni-cads are subject to a phenomenon known as "memory effect." The battery tends to "remember" the duration of service previously expected of it, so if you regularly use only 50 percent of the battery capacity, battery life will be severely reduced. Whenever possible, use the battery until it is completely dead. One way to do this is to leave the portable fax on and let the battery run dead.
- Batteries should be regularly recharged, even if they are not used. Recharge batteries every two to four months, or they may be permanently damaged.
- Some battery packs use lead-acid or gelled electrolyte batteries. These, like ni-cads, are sealed against leakage, but given the right circumstances all batteries may leak. When not in use, remove the battery and store it in a cool, dry place.

If the portable fax is not receiving power, check that the battery is properly charged. You can test the voltage of a battery to see if it is working properly, but this test might not be effective unless the battery is currently in use. Insert the battery in the fax and turn the unit on. Use your meter to measure the voltage output of the battery. It should be roughly the same as the rated voltage.

Check that the battery terminals are not corroded or broken. Clean the terminals if they are dirty or corroded; heavy corrosion or breakage must be repaired by replacing the terminals or battery compartment module. Use your meter to check the wiring from the battery compartment to the main board on the fax. You should get a reading all the way to the on-off switch.

Clearing paper jams

A common problem to all faxes is jammed paper. Jams can occur with the original document paper, as well as with the recording paper. Clearing paper jams is a rather sim-

ple process. Here are the methods for clearing thermal- and xerographic-type fax machines:

Clearing original document jams

Documents can jam in the works of a fax machine for any number of reasons:

- You've loaded too many pages into the automatic document feeder (ADF). Remove some pages.
- The document is creased, folded, or dog-eared. Try to smooth it out or make a duplicate of it on your plain-paper copy.
- A staple or paper clip is left on the page. Be sure to remove these because they can jam paper and harm the internal components of the fax.
- The paper is too thick, too thin, or too smooth. Make a duplicate of these documents with a plain-paper copier. Use the copy with your fax.

Paper jams can also occur when the paper transport rollers are dirty, worn, or broken, and the paper path is obstructed by some foreign object. If you are sure that the paper isn't causing the problem, inspect the rollers for damage. Try cleaning the rollers and the entire paper path.

Jams in thermal fax machines

The recording paper in thermal fax machines seldom jam because it's always clean and it leaves very little paper debris. However, when a jam does occur, inspect the paper and look for torn edges or corners. If the paper has been damaged, try to locate the remaining portions inside the fax machine. These errant scraps of paper, left over from previous jams, cause future problems. Be sure the paper is properly threaded into the machine. Refer to the instructions on how to correctly insert the paper into the fax.

Persistent jams can be caused by poor-quality paper. Also, your fax machine might prefer a different type or brand of paper. Try a different paper to see if jamming still occurs. Some fax machines prefer one type of paper over another (for example, a paper that exhibits less curl). Try a roll of several types to find the paper that's best for your machine. If the manual that came with your fax recommends a certain type of paper, use it if you can.

Other common causes of recording paper jams are:

- The paper roll is too small. Use the proper size recording paper. That is, if the machine calls for 50-meter rolls, be sure to use rolls that are 50 meters in length. Shorter paper can exhibit more curl and longer paper probably won't fit.
- The paper has been exposed to light, heat, or moisture. All three can cause a physical change in the paper and cause it to jam more readily.
- The paper is old. Fax machines prefer recording paper that is no more than one year old.

- The edge of the paper is heavily curled or creased after long periods without use. Remove this edge (about 5 to 6 inches should be enough) and rethread the paper into the machine.

As usual, stubborn jamming could be an indication of worn out parts. Fax machines contain few user-replaceable parts. If your fax is getting old, and jams are commonplace, you'll need to take your machine to a repair shop.

Jams in xerographic fax machines

Nothing is more annoying than halting your regular work to clear a paper jam in your plain-paper (xerographic) fax machine. An occasional jam (once every two or three hundred pages, for example) is to be expected—especially if the fax is more than a few years old. But if you are experiencing more frequent jams, your fax might need a thorough cleaning. It could also indicate you are using paper of substandard quality, or that the printing mechanism is worn out and should be overhauled.

If you feel that your fax machine is jamming too often, take time to clean it, both outside and in. Look out for shredded pieces of paper that might impede the smooth flow of paper during printing. If you are removing a jam, inspect the paper and look for torn edges or corners. If the paper has been damaged, try to locate the remaining portions inside the printer. Most likely, these errant scraps of paper left over from previous jams will cause future problems.

If the jams still occur, try replacing the cartridge or drum. If the old cartridge or drum is still good, wrap it tightly in a dark garbage bag, and place it out of the way so that it won't be tipped over or disturbed.

Persistent jams might be caused by poor-quality paper or paper that is not really designed for use in a xerographic fax machine (you can use the same paper that is designed for plain-paper office copiers and laser printers). Cheap paper can curl excessively in the fuser and cause jams that are particularly hard to clear. The fuser is a self-contained unit and it runs very hot during printing. If you are clearing a fuser jam, open the fax and wait until it cools down a bit. Otherwise, you could be seriously burned.

Heavy, linen letterhead stock might jam regularly in your fax, unless the paper is specifically made for use with plain-paper copiers or laser printers. Try a different type or brand of paper to see if jamming still occurs. Like spoiled household cats, some laser printers are more finicky than others. You might need to sample several types and grades of paper before you find one that's just right for your machine.

Stubborn jamming could be an indication of worn out parts. Other than the consumables, such as drum, toner, and developer, few fax machines include parts that you can easily replace. If your fax is getting old and jams are commonplace, you'll need to take it to the repair shop.

9

Maintenance and repair worksheet

Use the maintenance log in the following pages to track the routine upkeep and services you do with your facsimile machine. Feel free to make photocopies of these pages and keep the copies tucked under your fax machine or with the machine's manual. Remember: Maintenance logs are of little use unless you stick to them religiously. Make sure you write down anything and everything you do to your fax machine.

Filling out the worksheet

The worksheet consists of four pages.

- Page 1 includes general information about your fax machine for your own quick reference. The information in the fax vital statistics and fax design can be completed by looking for the model number and serial number at the rear or underside of your machine, and by referring to the manual that accompanies your fax. This information can be handy if you need to contact the manufacturer or arrange for professional service. You should also note the supplies you use for preventative maintenance. These records help with reordering and as useful information for subsequent service.
- Page 2 contains fill-in boxes for general maintenance, lubrication, and electrical contact cleaning. Enter the date, and check off the items that apply. If necessary, write a short note in the box if the service interval required anything out of the ordinary.
- Page 3 contains fill-in boxes for repair/replacement of parts. Enter the date, and check off the items that apply.
- Pages 3 and 4 contain entry blanks for problem occurrences. As problems occur, note the date, a description of the difficulty, the action taken, and any useful meter readings, measurements, etc.

Maintenance Log

Facsimile Machine Maintenance and Repair Log

Fax Vital Statistics

Brand _____
Model _____
Date Purchased _____ Serial Number _____
Where Purchased _____
Sales Person _____ Warranty Period _____
New _____ Used _____ If Used, How Old When Purchased? _____
Type: Ac Operated Home _____ Portable _____ Other _____
Original Document Feed: Pass Through _____ Flatbed _____

Fax Design

Printing Type: Thermal _____ Thermal Transfer _____ Xerographic _____
Paper Length: 15m _____ 30m _____ 50m _____ 100m _____
Features: Paper Cutter _____ Speed Dial _____ Gray Scale _____ ADF _____
Memory _____ Phone Handset _____ RS-232C _____ Activity Reports _____

PM Schedule Supplies (Type or Brand and Source)

Household Spray Cleaner _____
Non Petroleum-Based Solvent Cleaner _____
Optical Lens Cleaner _____
Oil Lubricant _____
Grease Lubricant _____
Electrical Contact Cleaner _____
Compressed Air _____
Rubber Cleaner _____
Other: _____

Tools (List)

_____
_____
_____

General Maintenance

Date				
Clean PCB				
Clean Printhead/optics				
Clean Transport				
Clean Controls				
Check Operation				
Inspect Wiring				

Lubrication

Date				
Original Document Feed				
Received Document Feed				
Paper Cutter				
Other_____				

Contact Cleaning

Date				
Power Swich				
Front Panel Switches				
Interlock Switches				
Remote Switches				
Remote Battery Terminals				
Connectors				
Misc_____				

Repair/Replacement

Date				
Drive Belt				
Drive Roller				
Paper Cutter				
ADF Paper Sensor				
Switch				
Original Doc. Feed Roller				
Received Doc. Feed Roller				
Main PCB				
Printhead Assembly				

Problem Occurrence

Date_____
Description of Problem_____
_____
_____
Action Taken_____
_____
_____
Meter Readings, Measurements, Etc._____
_____

Date_____
Description of Problem_____
_____
_____
Action Taken_____
_____
_____
Meter Readings, Measurements, Etc._____
_____

Problem Occurrence (Continued)

Date_____
Description of Problem_____
_____
_____
Action Taken_____
_____
_____
Meter Readings, Measurements, Etc._____
_____

Date_____
Description of Problem_____
_____
_____
Action Taken_____
_____
_____
Meter Readings, Measurements, Etc._____
_____

Date_____
Description of Problem_____
_____
_____
Action Taken_____
_____
_____
Meter Readings, Measurements, Etc._____
_____

Special Notes

_____
_____
_____
_____
_____

10

The computer-based fax

Even as recent as a few years ago, owning a facsimile machine meant you were a pioneer, a maverick of high technology. But today, not owning a fax means you're somehow out of tune, a reject of the in crowd.

No one likes to be a nerd, but even good fax machines aren't cheap. The typical cost is over $1,000 for a machine with modest features. Depending on your workload, that machine might sit—idle and forgotten—23 hours a day. If you're sure a fax lies somewhere in your future, and you are a personal computer owner, there's an alternative to the stand-alone fax route: fax modems.

What are computer faxes?

A computer fax connects between your computer and telephone line like a regular modem, but it is engineered specifically to send and receive facsimile documents.

Computer faxes are not quite complete substitutes for the real thing. The computer fax consists only of the data transmitting and receiving electronics; it lacks the document scanner and printer of a stand-alone fax. Depending on your application, this system could be a serious hindrance or a meaningless issue.

The ideal computer fax user is someone who regularly trades computer-generated data files and graphics. Paper copies are not routinely used. When they are, the computer fax can be augmented with a printer (to make paper copies) and an image scanner (to read originals). Although most computer owners have a printer, few have an image scanner. So, computer faxes are best suited to receive paper documents, not send them.

If you do have an optical scanner, you can use it to process the image of the pages into the computer. That way, you don't have to use computer prepared documents. You can transfer anything that you can fit into the scanner, including signed contracts, text/graphic reports, newspaper and magazine articles, etc.

Documents that are received by the computer fax appear on the screen and they can be stored on magnetic disk or transferred to paper with a suitable printer (dot matrix, laser, ink jet, or any other printer that is capable of graphics).

Pages can also be sent to other facsimile devices (stand-alone or computer) for your PC. The pages can either be screen images that are captured into the computer's memory or text documents that are transferred to fax-equivalent images.

Several advantages to computer faxes are:

- They work in the background so that you can send and receive fax documents while working in another computer application. As long as the fax board is connected to the phone lines, you can send and receive documents with almost no intervention on your part.
- They operate under software control, which can be regularly updated. As you'll read later in this chapter, all the features of your computer fax are built into the software, not the hardware. So, even "expensive" features (such as delayed broadcasting, multiple broadcasting, speed dialing, and more) can be cheaply implemented under software control.

No frills fax hardware

Computer faxes come in two forms:

- **Add-in board** These boards slip into the computer and connect by way of an internal expansion slot. Add-in fax boards are the most common type for use with the IBM PC and compatibles.
- **Stand-alones** Fax modems in-a-box that are external to the computer. A data cable connects between the computer and modem, and a phone cord between modem and telephone jack. Stand-alone computer faxes are the most common type for the Apple Macintosh.

Computer fax modems are close cousins to the regular telephone modem (in fact, many computer faxes also include a 1,200- or 2,400-bps data-communications modem). Most all fax modems are based on a proprietary IC chip set made by Rockwell (this standard is also shared among many stand-alone fax machines). This standard helps ensure compatibility between your fax modem and the several million Group 3 fax machines in the world.

Regular computer data-communications modems operate at 1,200 or 2,400 bps, but Group 3 fax modems are designed to operate at speeds of up to 9,600 bps (noisy phone lines can force the modem to lower transmission to a more comfortable speed). Obviously, the faster the transmission rate, the quicker your documents are funneled through the phone lines.

Consider: You send two five-page documents per day, long distance from Los Angeles to New York. At approximately 35 cents per minute (AT&T, daytime rates), you'll spend about $682 in long distance fax calls per year with a 4,800 bps computer fax. Your phone bill can be cut in half (a savings of $341) by using a 9,600-baud modem.

Many stand-alone fax machines are downward compatible to the older Group 2 and 1 standards, but this is seldom found in computer faxes. Though Group 3 is the modern

standard, some people still live in the Dark Ages. You might not be able to share faxes with them.

Fax document conversion

You can fax just about any document that you can create with your computer, including text and graphics files. However, computer faxes cannot simply yank a document from a word processor or graphics program and spit it out over the phone line. Before transmission actually begins, the software must convert the document to "fax-speak," the universal data format that is used by fax machines. As you read in chapter 2, this document format is special because it uses modified Huffman file compression to cram more bits in a smaller space.

Many of the documents you send through the fax board are in text-only ASCII format. All of the current boards have an automatic ASCII-to-fax conversion feature, so any text document you see on screen can be transmitted through the phone lines. And most boards (or their attendant software) convert PC paintbrush (PCX) files to standard facsimile images. Received fax documents are in graphics format, typically PCX, PCC, or TIF, all of which are used extensively in graphics and desktop publishing programs.

Since facsimile is graphic-based, the recipient sees the characters of the document in picture format. If the receiver also has a PC fax board, the received image is a graphic, not a text document.

The benefit of computer fax is fully realized when transmitting and receiving documents that have both text and pictures. Text and graphics are treated the same by the fax system, so you never have to worry about incompatibilities between the receiving and transmitting stations.

Remember that file compression takes time and it is dependent on the speed of your computer. If you own a hot-rod 80386 computer, your fax documents will convert in about 15 to 20 seconds per page. But if your computer is a slower XT or AT, expect one minute or two per page. These times assume the 196-by-203 line-per-inch fine resolution. Conversion time can be reduced by using the lower 98-by-203-line-per-inch standard resolution.

Once converted, the documents require the same amount of time to transmit as with any other stand-alone fax machine. That is, assuming 9,600 bps operation, expect roughly 18 seconds for standard resolution, and 35 seconds for fine resolution.

Computer faxes convert either "on-the-fly" while on-line with the remote fax, or "off-line" before picking up the phone. Both have advantages and disadvantages.

On-the-fly conversion requires less of your time, because the computer fax is doing two things at once. Even though the bulk of fax communication occurs in the background (while you're busy using another program on your computer), document conversion and transmission can consume microprocessor time and make the machine very sluggish. On-the-fly conversion doubles-up the process of conversion and transmission, so your documents are sent more quickly.

On the other hand, on-the-fly conversion means that you're on the phone for longer periods of time. If it's a long distance call, you'll be racking up the phone charges. You pay for the transmit time, as well as the conversion time. If you have many pages to

send, and are transmitting over long distances, you'll want a computer fax that converts the documents before initiating the call.

Many computer faxes let you select the conversion process, either on-the-fly or off-line. In addition, a number of graphics conversion programs, such as Hijack (from Inset Systems), include a fax translation option. Use the conversion program to create a "fax-speak" document, then send it directly through your computer fax.

Printing received fax documents

Faxes you receive through your computer can be printed on any printer that is capable of graphics. The printer must be supported by your fax software. The most commonly supported printers are the Hewlett Packard LaserJet and Deskjet printers, as well as dot-matrix models from IBM, Epson, C. Itoh, and Okidata. You cannot use a daisy-wheel or other formed-character printer; these printers are not capable of producing graphics.

Remember that received fax documents are really graphic images. Though they might contain writing, you can't "paste" the words into your word processor and edit them. You need optical character reader (OCR) software to convert the graphic image of the characters into true editable text. OCR software is available as a cost-extra option on most all fax boards.

Scanning original documents

Stand-alone facsimile devices scan an original that you insert into a slot in the machine. An optical system in the fax breaks the page into hundreds of horizontal lines, and transmits the lines serially through the phone link. Computer fax boards have no optical system, so they cannot scan originals. If you need to send printed documents through the fax system, you need a desktop scanner, such as those sold by Microtek, DEST, Princeton Graphics, AST, and Datacopy.

Scanners are expensive peripherals; the average price for a desktop image scanner is over $1,500, although you can purchase hand-held scanners for about $300. Hand-held scanners capture only a three or four inch-wide strip, so you can't get the entire page all at once. Many hand scanners come with software that links the strips into one cohesive graphic image.

Scanners are typically used in desktop publishing systems to convert original artwork into computer data so that pictures can be merged with text onto a desktop-published page. All scanners have a maximum image resolution that exceeds what is needed to send fax documents. The highest resolution of Group 3 fax transmission is superfine, at 200 by 400 lines per inch, but most applications call for just fine resolution of 200 by 200 lines per inch. Desktop scanners sport resolutions of 300 to 400 dots per inch (some go as high as 600 dots per inch). If you already have a scanner, it costs you nothing to use it with the computer fax. However, if a desktop scanner is not among the repertoire of your computer system and you need to transmit copies of original documents, you must add its cost to the price of the fax board. The advantage of purchasing a separate fax board and scanner instead of a stand-alone fax machine is that you can use the scanner for other applications.

Fax features

Computer faxes do more than transmit the image of documents. Most fax boards and software are loaded with additional features that make the computer fax more useful.

Computer installation

Fax boards can be installed in your computer like any other expansion card. The boards currently available are full-size, so you need a full slot to accommodate one. Because the board is really a modem, it functions as a serial COM port.

If you already have serial port in your computer, you must assign the fax board as COM2. In normal operation, you cannot plug in the board if you already have two COM ports installed. You must disable one COM port or the computer will not function properly. This can be a problem if you have a serial port installed for a plotter or printer and another installed for a modem (or as an internal modem).

Menu-driven software

Most computer fax software is menu-driven. With menu-driven software, you select the mode of operation and system parameters by choosing from on-screen commands. These commands make using the fax easier, especially for those who are not fully familiar with fax systems. An AUTOEXEC file allows you to automate the fax process so that the board is initialized and readied each time the computer is turned on.

Document formats

Received fax files can be saved in any of several formats. Most fax board software saves the received document in a proprietary file format, but you are often given the ability to select another format in case you need to share data across applications. As mentioned earlier, most fax boards save incoming documents in PC paintbrush (PCX) format, which ensures good compatibility with many PC applications programs.

Printer and screen compatibility

Because captured fax documents are graphic images, you need a visual display that is capable of reproducing graphics. A monochrome video adapter cannot be used unless it is capable of Hercules graphics. You can also use a color graphics adapter or an enhanced graphics adapter.

You'll want to print most of the documents you receive via the fax link. Your printer must be capable of graphics (daisywheel printers are out) and they must be supported by the fax board software. Most leading brands of dot matrix and laser printers are supported. You can print full pages on a laser printer if your printer has enough memory.

Computer faxes share many of the same standard features as stand-alone fax machines, including:

- **Standard phone hookup** Just plug the fax into an RJ-11/14 phone jack.
- **Dialing** Phone numbers can be entered from the keyboard or stored in a frequent-number file for instant retrieval.

- **Auto answer/reception** Have your computer fax automatically answer the phone and receive a fax.
- **Remote identification** Encode your name or phone number as the unique identification of your fax. This ID is flashed on the operator's panel (or video screen) of the remote fax.
- **Transmit and receive journals** Information about your calls are stored on disk so that you can review the calls sent and received with your computer fax.
- **Memory and data storage** The fax uses the memory and disk that is already installed in your computer; no need for extras.

Installing a computer fax board

Imagine an automobile where you can switch the transmission from manual to automatic simply by plugging in a new box. Add another two or three cylinders to the engine or change the body of the car from a hard top to a convertible. You can't do that with any car yet invented, but the same idea has already come to computers in the form of expansion boards.

The fax board is one such expansion card that lets you change the characteristics of your computer. It instantly turns your PC into a fully functional fax machine. Remember these tips when installing a fax board.

Work area

Before you install a fax board in your computer, make sure you have plenty of elbow room. Working in a cramped space invites trouble. Work only at a well-lit table that is covered with carpeting or soft fabric. A sheet of antistatic foam, if you have it, is even better. Before working inside the computer, be sure that the power to the computer is off and that the ac cord is unplugged. This precaution is vitally important for both you and your computer.

Starting work

The cover of the PC and some PC compatibles is fastened by screws. Remove them using the proper-type screwdriver. An increasing number of PC clones have flip-up tops, so no screwdriver is required.

The ICs and other components on the fax board can be damaged by static electricity. You carry a static charge wherever you go (even if the weather isn't dry), so before you take your computer apart or handle the board, first discharge the static from your body. The best way is to touch the metal chassis of any grounded appliance.

Switch/jumper setting

Most fax boards must be configured before you can install them inside your computer, usually to indicate the serial port (COM1 or COM2) that you wish to use. Almost all

boards use one of two methods to change the operating characteristics: miniature DIP switches or jumpers.

- *DIP switch blocks* look like integrated circuits with tiny switches on top.
- *Jumpers* are removable plastic and metal tubes that sit astride two connector pins.

No matter what your board uses, read the instructions carefully on how to set the DIP switches or jumpers to conform to your computer and setup.

If your computer already has two serial ports installed inside, you'll probably need to disable it. Otherwise, the serial port and fax board will compete with one another and the system won't work. Refer to the manual that came with your computer or to the serial port card for additional information.

Installing the board

Once you've set up your board and computer to accept the fax, install the board in an empty expansion slot. With the IBM PC or clone, you can put just about any board in any slot. Your only restriction is the length of interconnecting cables and the placement of other boards.

If you're installing a full-length card into the PC, remove the bracket cover beside the slot that you've chosen to use. If the board came with a plastic card guide, attach it to the inside chassis opposite the expansion slot that you are using.

During installation, handle the board by the edges and be sure not to touch the components or the narrow strips of metal on the edge connector. When inserting the board, be careful to line up the edge-connectors of the card with the expansion slot. If the expansion slot has never held a board before, the contacts inside it might be unusually stiff. An extra measure of pressure might be required to seat the board inside the connector.

Though you might need to press down to get the board into place, never force it. If you're having trouble inserting the board, look for any obstructions, then try again.

Once the board is in place, press down firmly but gently to make sure the board is completely seated into the connector. Then, attach the mounting bracket to the chassis.

Review

Before you close up the computer, inspect your handiwork and look for potential problems. Is the board completely into the expansion slot? It should be. Are all the cables firmly attached? Make sure they are. Are any brackets or other metal objects touching the card or computer circuit board? If so, correct the problem now.

If everything looks all right, replace the computer cover, plug the ac cord back into the wall outlet, plug the fax board into the telephone jack, and turn the computer on. With the PC and most clones, you'll be notified if things aren't working properly when the built-in diagnostic tests sense a potential problem. However, don't rely on the diagnostic tests to uncover all problems. You'll still need to thoroughly test the fax board.

Users of the 80286-, 80386-, and 80486-based computers must run a software utility each time the computer is reconfigured. The setup program lets you communicate the changes you've made to its insides to the computer. Setup is entirely prompt driven, so it's easy to use.

Software installation

Before the fax machine can be used, you'll need to install the appropriate software for it. This software is available with the computer fax board. Standard packages include:

- **Setup program** Run this program to install the software.
- **Document conversion program** Use this program to convert your applications documents to fax-speak and vice versa.
- **Communications software** Start this program when you want to send or receive a fax, maintain your phone number listing, change operating parameters, etc.
- **System drivers** When needed, these program files enable the fax board to be used in your computer. The drivers are generally loaded into the computer's memory at start-up. Rather than run these programs yourself, the computer executes them from the AUTOEXEC.BAT and/or the CONFIG.SYS files.

Because of the size of fax software—not to mention the huge files created by fax documents—you'll need a hard disk for proper operation. You should allow about 3 to 4 megabytes for fax program and document files.

Testing

Once the software is installed, you can test the fax board. The procedure is usually outlined in the manual that accompanied the board. Lacking specific test guidelines, perform the following:

1. Use the conversion program to translate an ASCII (text-only) document to a fax format. ASCII files are handled by all the conversion programs, and they pose the fewest problems.
2. Arrange with a friend or associate who has a fax machine to send a file for testing purposes. Or, if you have a stand-alone fax, merely send it to yourself.
3. Repeat the process with your computer fax on the receiving end. Receive a one- or two-page document and store it on disk.
4. Use the conversion program to convert the received document to a graphic image file. Use the conversion program to view the file, or load it into an applications program (like Microsoft Word for Windows or WordPerfect) that can read PCC- and PCX-format graphics files.

Table 10-1. Basic Troubleshooting Guide, Fax Computer Board.

PROBLEM	**CAUSE**	**REMEDY**
Doesn't respond	Not inserted in slot	Reject installation
	Incorrect setup	Reset (DIP switches, jumpers, etc.)
Won't place call/answer call	Not connected to phone line	Connect
	Bad phone line/outlet	Inspect and replace, as necessary
	Problem with phone circuits	Wait; call phone company if not resolved
Won't read document	Incorrect document format	Reconvert
	File too big	Free RAM (or add more RAM)
Won't display received document	Incorrect document format	Reconvert
	File too big	Free RAM (or add more RAM)
	Problem in transmission	Retransmit
Incomplete transmission/reception	Noisy phone line	Try again
	Bad phone line	Attempt repair; call phone company
	Incorrect software settings	Review settings; correct as necessary
Blotches, lines, etc. in received	Noisy phone line	Try again
	Bad phone line	Attempt repair; call phone company
	Bad conversion	Reconvert
Fax does not respond to controls	Incorrect software settings	Review settings; correct as necessary
	Incorrect parameter setup	Reset parameters
	Hardware "crash"	Turn computer off and on again

During these tests, watch for any inconsistencies, such as errors that you've never encountered before or sluggish operation. If you find an operational problem, see if the manual included with the board has a troubleshooting section. Look up the problem there. If you can't pinpoint the problem, check your installation one last time, then refer to your dealer or the manufacturer.

Possible problems

If you follow the manufacturer's instructions for installing and using your computer fax board, you shouldn't have many problems. However, difficulties sometimes do occur. TABLE 10-1 lists problems that are common to fax boards in IBM PC and compatible computers. Suggested fixes are provided. You should also consult the manual that came with your computer fax board for additional troubleshooting tips.

Appendix A

Sources

Facsimile machine manufacturers

AEG OLYMPIA INC.
Box 22
Somerville, NJ 08876
(201) 231-8300

AT&T
1 Speedwell Ave.
Morristown, NJ 07960
(800) 247-1212

BROTHER INTERNATIONAL CORP.
8 Corporate Place
Piscataway, NJ 08855
(201) 981-0300

CANON USA, INC.
Printer Division
One Canon Plaza
Lake Success, NY 11042
(516) 488-6700

CBM AMERICA (CITIZEN BUSINESS MACHINES)
2020 Santa Monica Blvd., Ste. 410
Santa Monica, CA 90404
(213) 828-8245

CODE-A-PHONE CORP.
16261 E. 130th
Clackamas, OR 97015
(503) 655-8940

ELEC & ELTEK (USA) CORP.
1230 Oakmead Parkway, Ste. 310
Sunnyvale, CA 94086
(408) 732-1181

EPSON AMERICA
2780 Lomita Blvd.
Torrance, CA 90505
(213) 539-9140

FUJITSU AMERICA INC.
3055 Orchard Dr.
San Jose, CA 95134
(408) 432-1300
(800) 626-4686

GESTETNER CORP.
Gestetner Park
Yonkers, NY 10702
(914) 968-6666

HITACHI AMERICA LTD.
Telecommunications Division
2990 Gateway Dr.
Norcross, GA 30071
(404) 446-8820

KONICA BUSINESS MACHINES
USA, INC.
500 Day Hill Road
Windsor, CT 06095
(203) 683-2222

LANIER
2300 Parklane Dr. NE
Atlanta, GA 30341
(404) 446-9124

MEDBAR ENTERPRISES
71-08 51st Ave.
Queens, NY 11377
(718) 335-0404

MINOLTA CORP.
101 Williams Dr.
Ramset, NJ 07466
(201) 825-4000

MITA COPYSTAR AMERICA INC.
Heights Plaza
777 Terrace Ave.
Hasbrouck Heights, NJ 07604
(201) 288-6900

MURATA BUSINESS SYSTEMS
5560 Tennyson Parkway
Plano, TX 75024
(214) 403-3300
(800) 347-3295

NEC AMERICA INC.
8 Old Sod Farm Rd.
Melville, NY 11747
(516) 753-7000

NISSEI ELECTRIC USA INC.
3 Reuten Dr.
Closter, NJ 07624
(201) 768-0085

OKIDATA
532 Fellowship Rd.
Mt. Laurel, NJ 08054
(800) 654-3282

OLIVETTI USA
Office Products Division
765 US Highway 202
Somerville, NJ 08876-1289
(201) 526-8200

OMNIFAX
8700 Bellanca Ave.
Los Angeles, CA 90045
(213) 641-3690

PANASONIC COMMUNICATIONS &
SYSTEMS CO.
Two Panasonic Way
Secaucus, NJ 07094
(201) 348-7000

RELISYS
320 South Milpitas Blvd.
Milpitas, CA 95035
(408) 945-9000

RICOH CORP.
5 Dedrick Place
West Caldwell, NJ 07006
(201) 882-2000

ROYAL IMAGING SYSTEMS
765 US Highway 202
Somerville, NJ 08876
(201) 526-8200

SANYO BUSINESS SYSTEMS CORP.
51 Joseph St.
Moonachie, NJ 07074
(201) 440-9300

SAVIN CORP.
PO Box 10270
9 West Broad Street
Stamford, CT 06904
(203) 967-5000

SHARP ELECTRONICS CORP.
Sharp Plaza
Mahwah, NJ 07430-2135
(201) 529-9500

STAR SIGNAL
300 Orchard City Dr. #131B
Campbell, CA 95008
(800) 729-7100

TANDY CORP./RADIO SHACK
1800 One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

TOSHIBA AMERICA INC.
Information Systems Division
9740 Irvine Blvd.
Irvine, CA 92718
(714) 583-3000
(800) 547-7777

TRANS-LUX
110 Richards Ave.
Norwalk, CT 06854
(203) 853-4321

XEROX CORP.
100 Clinton Ave. South
Rochester, NY 14644
(716) 423-5078

Fax board and modem manufacturers

ABATON
48431 Milmont Dr.
Fremont, CA 94538
(800) 444-5321

ADTECH MICRO SYSTEMS, INC.
43120 Christy St.
Fremont, CA 94538
(415) 659-0756

ADVANCED MICROCOMPUTER SYSTEMS
1321 Northwest 65th Place
Fort Lauderdale, FL 33309
(305) 975-9515

APPLE COMPUTER, INC.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
(408) 973-2222

AT&T
1 Speedwell Ave.
Morristown, NJ 07960
(800) 247-1212

CIRCUIT RESEARCH CORP.
4 Townsend W., Ste. 3
Nashua, NH 03063
(603) 880-4000

THE COMPLETE PC
521 Cottonwood Dr.
Milpitas, CA 95035
(408) 434-0145

COMPUTER FRIENDS
14250 NW Science Park Dr.
Portland, OR 97229
(503) 626-2291

CYPRESS RESEARCH CORP.
766 San Aleso Ave.
Sunnyvale, CA 94086
(408) 745-7150

DATA RACE
12758 Cimarron Path, Ste. 108
San Antonio, TX 78249
(512) 692-3909

DOVE COMPUTER CORP.
1200 N. 23rd St.
Wilmington, NC 28405
(800) 622-7627

FREMONT COMMUNICATIONS CORP.
46309 Warm Springs Blvd.
Fremont, CA 94539
(415) 438-5001

GAMMALINK
2452 Embarcadero Way
Palo Alto, CA 94303
(415) 856-7421

GLOBAL VILLAGE COMMUNICATION
1204 O'Brien Dr.
Menlo Park, CA 94025
(415) 329-0700

HOMLES MICROSYSTEMS, INC.
2620 South 900 W.
Salt Lake City, UT 84119
(801) 975-9929

HYBRID FAX INC.
978 Hamilton Ct.
Menlo Park, CA 94025
(415) 325-0600

MICRO ELECTRONIC TECHNOLOGIES, INC.
35 South St.
Hopkinton, MA 01748
(508) 435-9057

OMNIUM CORP.
PO Box 186
1911 Curve Crest Blvd.
Stillwater, MN 55082
(612) 430-2060

ORCHID TECHNOLOGY
45365 Northrop Loop W.
Freemont, CA 94538
(415) 683-0342

PANASONIC COMMUNICATIONS & SYSTEMS CO.
Two Panasonic Way
Secaucus, NJ 07094
(201) 348-7000

PRODUCT R&D CORP.
1191 Pacific Street, Ste. 201
San Luis Obispo, CA 93401
(805) 546-9713

PROMETHEUS PRODUCTS, INC.
7225 SW Bonita Rd.
Tigard, OR 97223
(503) 624-0571
(800) 477-3473

Q/COR
One Quad Way
Norcross, GA 30093-2919
(400) 923-6666
(800) 548-3420

RICOH CORP.
5 Dedrick Pl.
West Caldwell, NJ 07006
(201) 882-2000

SAVIN CORP.
PO Box 10270
9 West Broad St.
Stamford, CT 06904
(203) 967-5000

SKYWORLD TECHNOLOGY
1772 Lark Lane
Sunnyvale, CA 94087
(408) 446-9392

SPECTRA FAX
209 S. Airport Rd.
Naples, FL 33942
(813) 643-5060

STF TECHNOLOGIES, INC.
I-70 & Hwy 23
PO Box 81
Concordia, MO 64020
(816) 463-2020
(800) 426-1679

TOUCHBASE SYSTEMS
160 Laurel Ave.
Northport, NY 11768
(516) 261-0423

XECOM INC.
374 Turquoise St.
Milpitas, CA 95035
(408) 945-6640

XEROX IMAGING SYSTEMS, INC.
535 Oakmead Parkway
Sunnyvale, CA 94086
(408) 245-7900
(800) 248-6550

Fax-related products and accessories

AMBICO
50 Maple Street
Norwood, NJ 07648
(201) 767-4100
Cleaning supplies, cables, etc.

BIB AUDIO/VIDEO PRODUCTS
PO Box 27682
Denver, CO 80227
(303) 972-0410
Cleaning supplies, cables, accessories, etc.

BP ELECTRONICS
260 Motor Parkway
Hauppauge, NY 11788
(516) 435-8777
Cleaning supplies and accessories.

BUSH INDUSTRIES
One Mason Drive
PO Box 460
Jamestown, NY 14702
(800) 228-2874
Cabinets.

GUSDORF
11410 Lackland Road
St. Louis, MO 63146
(314) 567-5249
Cabinets.

O'SULLIVAN INDUSTRIES
1900 Gulf Street
Lamar, MO 64759
(417) 682-3322
Cabinets.

PANAMAX
150 Mitchell Blvd.
San Rafael, CA 94903-2057
(800) 472-5555
(800) 443-2391
Power/phone line surge protectors.

RDI RESEARCH
955 Massachusetts Ave., Ste. 329
Cambridge, MA 02139
(514) 733-8065
Fax/voice switches.

RECOTON
46-23 Crane Street
Long Island City, NY 11101
(718) 392-6442

Accessories.

TECHNOLOGY CONCEPTS INC.
1159 Triton Dr.
Foster City, CA 94404
(415) 349-0900
(800) 852-6881

Fax voice/data switches and fax-to-laser printer interfaces.

VSI TELECOMMUNICATIONS INC.
9329 Douglas Dr.
Riverside, CA 92503-5618
(800) 999-8283

Fax/voice switches.

Fax parts and test equipment

ANDREWS ELECTRONICS
25158 Avenue Stanford
Valencia, CA 91355
(800) 274-4666

Fax and electronics replacement parts.

C & S SALES, INC.
1245 Rosewood
Deerfield, IL 60015
(800) 292-7711
(708) 541-0710

Test equipment.

CIRCUIT SPECIALISTS, INC.
PO Box 3047
Scottsdale, AZ 85271-3047
(800) 528-1417
(602) 966-0764

Test equipment, replacement electronic parts, cleaning supplies.

GMB ELECTRONICS SUPPLY
140 Terminal Road
Setauket, NY 11733
(800) 874-1765
(516) 689-3400

Fax and electronics replacement parts.

HEATH CO.
PO Box 8589
Benton Harbor, MI 49022
(800) 253-0570

Test equipment (kits and assembled).

MCM ELECTRONICS
650 Congress Park Dr.
Centerville, OH 45459-4072
(800) 453-4330

Fax and electronics parts, cleaning supplies (including Re-Grip), and test equipment.

MOUSER ELECTRONICS
2401 Hwy 287 North
Mansfield, TX 76063
(800) 992-9943

Fax and electronics parts, electronic replacement parts, test equipment.

PARTS EXPRESS
340 E. First St.
Dayton, OH 45402
(513) 222-0173

Repair parts and cleaning supplies.

TANDY CONSUMER PARTS
7439 Airport Freeway
Fort Worth, TX 76118
(800) 243-1311

Replacement parts for Radio Shack/ Realistic fax, plus OEM brands.

TRITRONICS
1306 Continental Drive
Abington, MD 21009
(800) 638-3328
(301) 676-7300

Fax and electronics replacement parts.

UNION ELECTRONIC DISTRIBUTORS
16012 Cottage Grove
South Holland, IL 60473
(800) 648-6657
(312) 333-4100 or (312) 468-7300

Fax and electronics replacement parts.

Parts centers

These companies have stipulated that parts and service information are to be obtained from the following addresses

CANON, EAST COAST
Canon Parts Center
Cantiague Rock Road
Westbury, NY 11590-1708
(516) 876-6500

CANON, WEST COAST
Canon Parts Center
123 Paularino Ave. East
Costa Mesa, CA 92626
(714) 850-6376

EASTMAN KODAK COMPANY
Parts Services
800 Lee Road
Rochester, NY 14650
(716) 724-7278

PANASONIC/MATSUSHITA
Matsushita Services Company
50 Meadowland Parkway
Secaucus, NJ 07094

Contact manufacturer for an authorized replacement parts distributor near you.

NEC TECHNOLOGIES, INC.
Attention: Parts Order Department
1255 Michael Dr.
Wood Dale, IL 60191
(708) 860-0335

SHARP ELECTRONICS CORPORATION
Sharp Plaza
PO Box 650
Mahwah, NJ 07430-2135

Contact manufacturer for an authorized replacement parts distributor near you.

TANDY CONSUMER SERVICE PARTS
7439 Airport Freeway
Fort Worth, TX 76118
(817) 284-8691
(800) 243-1311

TANDY ELECTRONICS
Tandy Electronics National Parts Division
900 East Northside Dr.
Fort Worth, TX 76102
(817) 870-5600
(800) 442-2425

TOSHIBA AMERICA CONSUMER
PRODUCTS
82 Totowa Rd.
Wayne, NJ 07470

Contact manufacturer for an authorized replacement parts distributor near you.

Other important addresses

ELECTRONICS INDUSTRY ASSOCIATION
(EIA)
Consumer Electronics Group
2001 Pennsylvania Ave. NW
Washington, DC 20006-1813

Appendix B

Further reading

Interested in learning more about fax and fax machines? Here is a selected list of magazines and books that can enrich your understanding and enjoyment of the world of facsimile.

Magazines

Buyer's Guide to Cellular and Fax Special issues published occasionally throughout the year report on latest fax machines (and cellular phones). Includes review of the latest models.

Radio-Electronics A monthly magazine for electronics hobbyists. It occasionally features technical articles on fax machines and fax communications, with some buyer's guides on faxes and related hardware.

Popular Electronics *Popular Electronics* is a monthly magazine for electronic hobbyists, but it is often less "techie" than its sister magazine, *Radio-Electronics.*

Books

Basic Electronic Test Procedures—2nd Ed.; Irving M. Gottlieb, TAB Books, Catalog #1927.

How to take in- and out-of-circuit electronic measurements using volt-ohm meters, oscilloscopes, and other common test gear.

Beginners Guide to Reading Schematics, 2nd Edition; Robert J. Traister and Anna L. Lisk, TAB Books, Catalog #3632.

How to read and interpret schematic diagrams.

Digital Electronics Troubleshooting; Joseph J. Carr, TAB Books, Catalog #1250.
Theory and practice of troubleshooting digital circuits.

Handbook of Electronic Safety Procedures; Edward A. Lacy, TAB Books, Catalog #1420.
Covers safety precautions and procedures when troubleshooting and repairing electric and electronic devices.

How to Troubleshoot & Repair Electronic Circuits; Robert L. Goodman, TAB Books, Catalog #1218.
General troubleshooters guide for both analog and digital circuits.

Installing Your Own Telephones, 2nd Edition; Master Publishing (available at Radio Shack).
How to install new phones, extensions, outlets, etc.

Meters and Scopes, How to Use Test Equipment; Robert J. Traister, TAB Books, Catalog # 2801.
How to properly use oscilloscopes, volt-ohm meters, and other electronic testing gear.

Principles and Practice of Electrical and Electronics Troubleshooting; D. Tomal and D. Gedeon, TAB Books, Catalog #1842.
General tips on making electronic measurements and troubleshooting procedures.

How to Test Anything Electronic, 2nd Edition; Jack Darr and Delton T. Horn, TAB Books, Catalog #2925.
General introduction to testing procedures and test equipment.

Understanding Digital Electronics; R. H. Warring, TAB Books, Catalog #1593.
Introduction to the principles of digital theory.

Understanding Electronics, Third Edition; Warring/Stone, TAB Books, Catalog #3044.
Introduction to the principles of electronic theory.

Video and audio cassettes

The following video cassettes are available from the Electronic Industry Association (EIA):

EIA/CEG
Department PS
2001 Pennsylvania Ave. NW
Washington, DC 20006-1813

Troubleshooting with Modern Electronic Test Equipment (Part 1): The Oscilloscope. Running time: 45 minutes.

Troubleshooting with Modern Electronic Test Eqipment (Part 2): General Test Instruments. Running time: 22 minutes.

High Technology Soldering. Running time: 15 minutes.

Appendix C

Soldering tips and techniques

Successful fax machine repair depends largely on how well you can solder two wires together. Soldering sounds and looks simple enough, but it really is a science. If you are unfamiliar with soldering or if you want a quick refresher course, read this short soldering primer.

Tools and equipment

Good soldering requires the proper tools. If you don't have them already, they can be purchased at most any electronics store.

Soldering iron

You'll need a soldering iron, of course, but not just any old soldering iron. Get a soldering "pencil" with a low-wattage heating element. For electronics work, the heating element should not be higher than about 30 watts. Most soldering pencils are designed so that you can change heating elements as easy as changing a light bulb.

Do not use the instant-on type soldering guns, which were favored in the old tube days. They create far too much unregulated heat and they are too large to effectively solder most joints on a printed circuit board (PCB).

If your soldering iron has a temperature control and readout, dial it to between 665 and 680 degrees. This temperature provides maximum heat with the minimum danger of damage to the electronic components. When you are not using your soldering iron, keep it in an insulated stand. Don't rest the iron in an ashtray or precariously on the carpet. You or some precious belonging is sure to be burned.

Soldering tip

The choice of soldering tip is important. For best results, use a fine tip that is designed specifically for printed-circuit board use. Tips are made to fit certain types and brands of heating elements, so be sure you get the kind for your iron. If the tip isn't pretinned, tin it by attaching the tip to the iron and heating it. After the iron is hot, apply a thin coat of solder to the entire tip.

Sponge

Keep a damp sponge by the soldering station and use it to wipe off extra solder. You'll have to rewet the sponge now and then if you are soldering a lot.

Solder

You should use only rosin-core solder. It is available in different thicknesses; for best results, use the thin type (0.050″) for PCB work. Never use acid core or silver solder on electronic equipment.

Soldering tools

Basic soldering tools include a good pair of small needle-nose pliers, tweezers, wire strippers and wire cutters (sometimes called *side* or *diagonal cutters*). The stripper should have a dial so that you can select the appropriate gauge to strip. A pair of "nippy" cutters, which cut wire leads flush to the surface of the board, are handy, but not absolutely essential.

Cleaning supplies

After soldering, and when the components and board are cool, spray or brush on some flux remover. Isopropyl alcohol can also be used for cleaning.

Solder vacuum

A solder vacuum is a suction device that is used to pick up excess solder. It is often used when desoldering—removing a wire or component on the board. Solder can also be removed with a length of copper braid. Most electronics stores sell a spool of it specifically for solder removal.

Basic soldering

The basis of successful soldering is that the soldering iron is used to heat up the work, whether it is a component lead, a wire, or whatever. Then, apply the solder to the work. Do not apply solder directly to the soldering iron. If you take the shortcut by melting the solder on the iron, you might end up with a "cold" solder joint. A cold joint doesn't adhere well to the metal surfaces of the part or board, so the electrical connection is impaired.

Once the solder flows around the joint (and some will flow to the tip), remove the

iron and let the joint cool. Avoid disturbing the solder as it cools; a cold joint might result. Do not apply heat any longer than necessary. Prolonged heat can ruin electronic components. Generally, if the iron is on any one spot for more than five seconds, it's too long.

If at all possible, keep the iron at a 30- to 40-degree angle to work, as shown in FIG. C-1. Most tips are beveled for this purpose.

Apply only as much solder to the joint as is required to coat the lead and circuit board pad. A heavy-handed soldering job might lead to *soldering bridges*, one joint that has been melded with joints around it. At best, solder bridges cause the circuit to not work; at worse, they cause short circuits that can burn out the entire board.

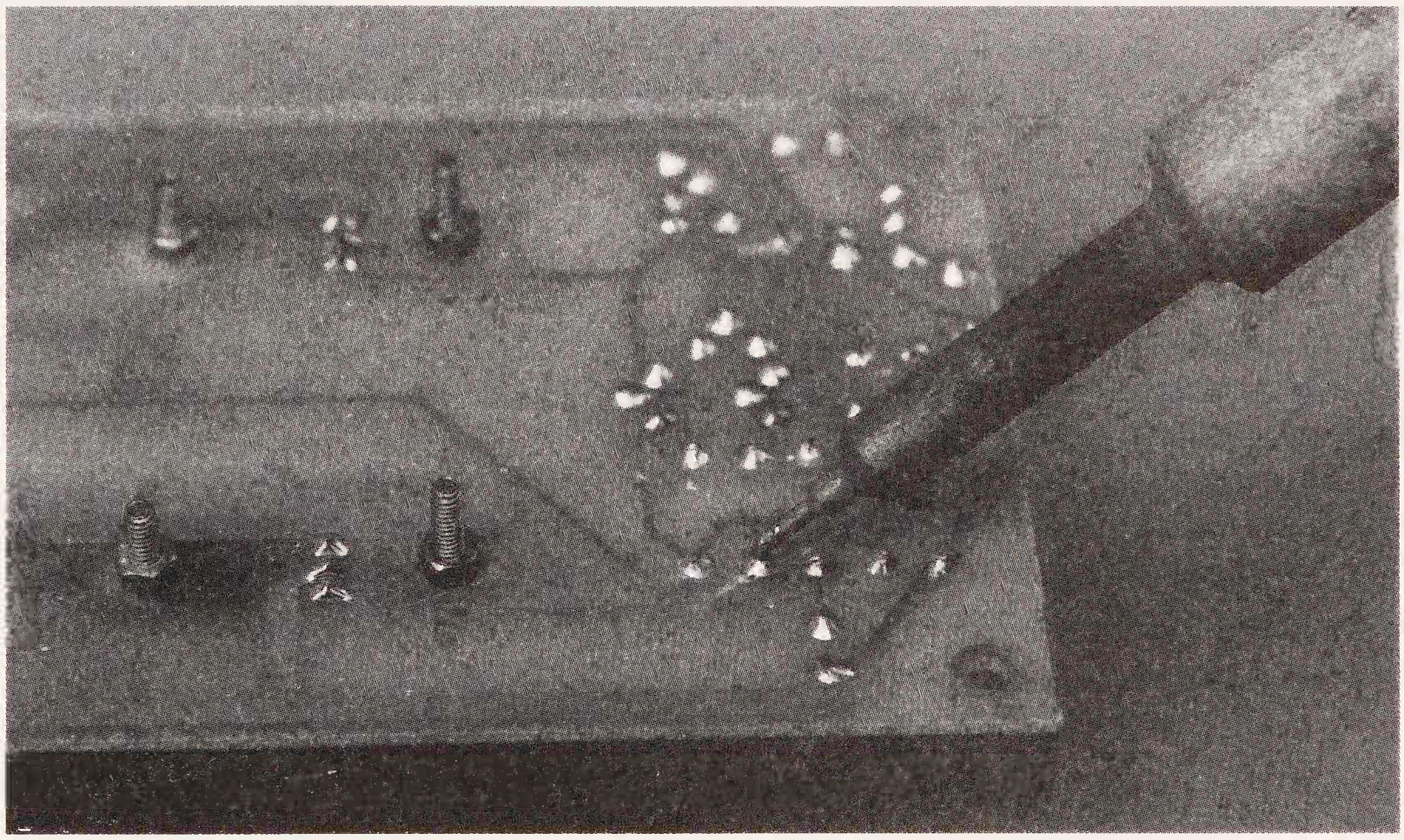


Fig. C-1. Proper soldering technique.

Replacing components

To replace a soldered component, first remove all the solder that holds it in place. Use the soldering iron to melt the joint, and as the solder flows, suck it up with a solder vacuum or wick it up with a copper mesh. Remove enough solder so that the component lead is free. If you can't get all the solder up the first time, let the joint cool and try again.

Clean the old joint and the leads of the replacement component in alcohol. This technique removes any oil that might impair the grip of the joint after soldering.

Insert the new component gently. Don't pull on the lead or you might damage the component. Once the part is seated on the board, bend the leads slightly to keep it in place. Solder as usual. If you are resoldering a wire onto a terminal, wrap the stripped end of the wire around the eyelet of the terminal before soldering.

A good solder joint

A good solder joint should be bright and shiny. A joint that looks dull is probably cold and it should be remade. The joint should not have any sharp "peaks." If so, the solder didn't flow well enough to make a good connection. Remake the joint and be sure to apply the solder to the work and not to the iron. Excess solder that forms on the tip (another cause for the peaks) should be removed with the damp sponge.

Electrostatic discharge

Electrostatic discharge, better known as a "carpet shock," can ruin electronic components. Remove the excess static buildup from your body by touching some grounded metal object before soldering or handling electronic parts and boards. If you are soldering transistors and ICs, use a grounded soldering iron, as well as an antistatic wrist band and table mat.

Tip maintenance and cleanup

After soldering, let the iron cool. Loosen the tip from the heating element and store it for next use. After several soldering sessions, clean the tip with a soft brush. Don't file it or sand it down with emery paper.

Invariably, little nuggets of solder will be left around after a repair job. Make sure that these balls of once-molten solder balls are not left on the PCB or inside the fax. The solder might bridge wires or board traces together and cause a serious short circuit. Inspect your work carefully and use a soft brush to wisk away stray bits of solder.

Appendix D

Fax troubleshooting charts

Here are the troubleshooting charts, in their order of presentation. The charts are numbered for cross-reference. Within the charts, the steps (or levels) are numbered, which correspond to numbers in the text. Unless otherwise specified, all troubleshooting procedures and tests should be done with the fax turned off, and unplugged or removed from the power source.

Fax does not turn on

The fax is dead. Nothing, even kind words, revive it. Pushing the power switch has no effect and the front panel controls are inoperative. Here is what to look for.

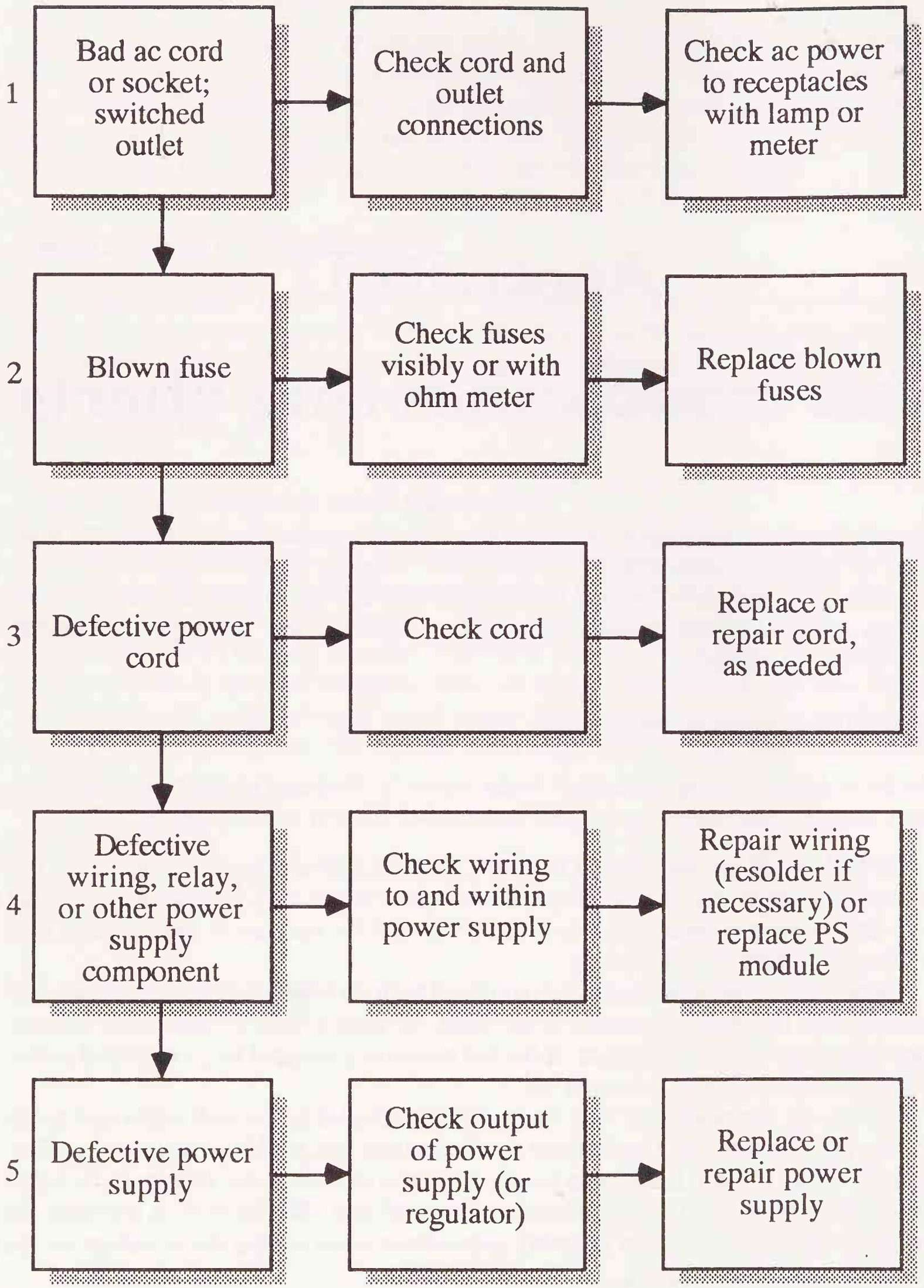
Step 1-1 If the fax runs on ac power, the first logical step is to ensure that it is getting power from the ac wall source. Make sure that the cord is plugged in and that the polarized plug is inserted properly. Do not defeat the purpose of the polarized plug by filing or cutting the wide prong.

Many offices and most homes are equipped with switched outlets—you flick a wall switch to turn the outlet on and off. Sometimes, the switch controls both outlet receptacles; other times, it only affects on. If the fax machine is plugged into a switched outlet, make sure that the outlet is turned on.

To rule out the possibility that the problem originates in the wall outlet and not in the fax, plug a lamp into a socket and see if the lamp works. If the lamp glows, obviously the outlet is good. If the lamp seems dim, carefully check the voltage at the outlet with a volt-ohm meter. It should read between 108 and 125 Vac (117 is average). Be absolutely sure that you follow all safety precautions when testing the ac voltage or you could receive a serious shock.

Step 1-2 A blown fuse will prevent your fax machine from operating. If your fax is equipped with an external fuse, remove it and visually inspect it. If you can't see if the fuse has blown, use a meter to check continuity. Attach the leads to either side of

1. Fax does not turn on



the fuse. If the fuse is good, the meter will read 0 ohms. Anything else indicates a bad fuse.

Many fuses are located inside the machine, on or near the power-supply section. You must remove the cover of the fax to inspect the internal fuses. Some fuses are soldered in place, but can be tested using a volt-ohmmeter. You should get a reading of 0 ohms when the test leads contact either side of the fuse. Be absolutely sure that the fax machine is off and unplugged when testing fuses.

If the fuse is bad, use an exact replacement only. If the value of the fuse is 0.375 amp, do not use a 1-amp fuse, etc.

Step 1-3 After checking the ac sources and fuse(s), inspect all power cords for cracks and other signs of wear. A badly worn or damaged cord can cause a number of problems. A short will blow fuses (either in the house or office, or in the fax machine); an open line will prevent ac from reaching the machine.

Check the continuity of the power cord with a meter. An open will register infinite ohms when the test leads are connected across the two prongs of the ac cord. A short will register 0 ohms.

Step 1-4 The power wiring inside the fax machine could be faulty. Open the machine and check the connections that lead to the power switch. Check for shorts and open circuits with the meter. Normally, only one side of the incoming ac is connected to the switch. The other side should connect directly to the power transformer.

If the fax has a power relay, check that it is getting power. The relay is usually located near the power transformer; check the heavy wires (the two smaller wires lead to the power switch and carry a low voltage only). Plug the machine in and set the meter to ac volts. Connect one test lead of the voltmeter to ground and the other to the incoming wire going to the relay. It should have power. Now, attach the lead to the other power terminal on the relay. With the relay off, it should have no power. Turn the fax power switch on and the meter should register approximately 117 Vac.

If the readings are erroneous, test the continuity of both the coil and the relay terminals. The coil should remain continuous, but the contact terminals should be shorted when on and open when off.

If the wiring to the switch (or relay) tests OK, try the wiring that goes from the switch to the inputs of the power transformer, the primary. Also test the wiring from the output of the transformer, the secondary, to the power-supply section or main printed circuit board.

To test whether the transformer is delivering power, plug in the machine (if it is safe) and turn it on. With the meter set to read ac volts in a range of no less than about 25 to 50 volts, connect the test leads to the outputs (secondary) of the transformer. Without a schematic, it might be difficult to make sense of the reading, but generally you should get a reading of 6 to 24 volts when connecting the leads to any of the wires.

The power transformers used in most fax machines have more than one tap-off point, so applying the leads at various tap-off terminals yields a variety of voltage levels. You can be fairly sure that the transformer is working properly if you get some readings when the meter is connected to most of the secondary wires. Be sure to avoid the primary wires, because they carry the full 117 Vac from the wall outlet.

Step 1-5 If you get a reading in the transformer secondaries but the fax still appears inactive, a problem is probably in the power supply board. A burned-out voltage regulator will cause partial or complete loss of function; similar results will occur if a capacity or other power supply component is shorted. Visually inspect the power supply section and look for charred components. Look especially at the voltage regulators (most often attached to metal heatsinks that help dissipate heat) and the large filter capacitors.

A defective voltage regulator might be hard to spot visually, but it can be checked with a voltmeter. For best results, refer to a schematic to determine the power test points. The regulator could have several pins and the pins might not be identified on the printed circuit board (PCB). Black charring or an oozing, dark substance around a large electrolytic capacitor indicates trouble. Replace the capacitor with the same value (both in microfarads and in voltage) or replace the entire power supply module.

The fax only turns on

It is often harder to troubleshoot a fax when the machine turns on, but nothing else. However, at least you can rule out problems in the power supply, fuses, on/off switch, and relay.

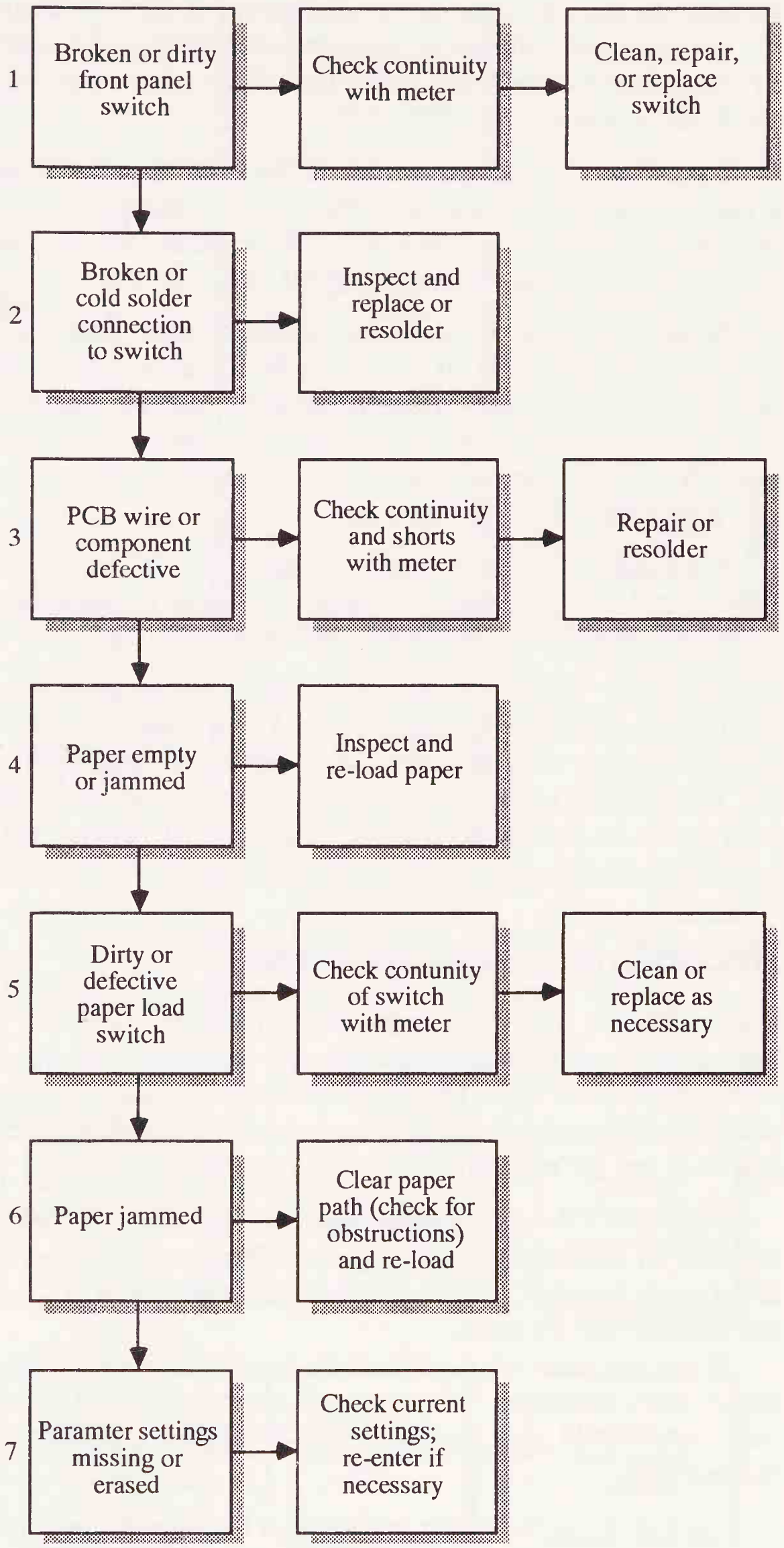
Step 2-1 You might not be able to control the operation of the fax machine if one or more of the front-panel switches are dirty or broken. If only one switch is affected, you might be able to cycle the machine through its other operations. You can isolate that switch by finding its solder contacts or connecting wires on the switch-panel PCB (the switch panel might be a part of the main PCB in some units). Use the volt-ohmmeter to test the continuity of the switch. Pushing the switch should change the reading from 0 to infinite ohms, or vice versa.

Step 2-2 If all the front-panel switches are inoperative, the problem could lie in the common connecting wire that runs to all switches (if applicable) or to the front-panel PCB. With the meter, test all the wires that lead to the switch panel to make sure none are broken or loose. With the test leads connected to either side of the wire, a reading other than 0 ohms is an indication of an internal break in the wire. Inspect the solder points for signs of a cold or incomplete solder joint. Resolder the joint if necessary.

With many machines, the front-panel PCB is attached to the main PCB by connectors. Use your meter to test the continuity between the connectors. If you find a reading other than 0 ohms, carefully remove the connector and inspect it for loose wires, broken wires, and broken or dirty contacts. Resolder or replace the connector if it is damaged. Use a recommended cleaner to clean contact points.

Step 2-3 If the problem still persists, the next logical step is to examine the wires and components on the main PCB. Are any wires obviously broken? Test with a meter to be sure. Look closely at the capacitors and resistors on the board. Occasionally, you can spot a burned-out component by looking for black charring on and around it.

2. Fax turns on but nothing else



Generally, you cannot spot a blown transistor or integrated circuit in this manner because the damage does not usually extend to the exterior or the device (because of the low operating voltages in these devices). Refer to the service manual, if available, for the proper voltage levels at the pins of the transistors and ICs. Use your meter to check the voltages.

Step 2-4 In many fax machines, standard operation is suspended when no paper is loaded or when the paper is jammed. Most of the times, but not always, these conditions are reported in the machine's LCD panel or "trouble" indicators. Double check the paper supply, and reinsert the paper just to be sure.

Step 2-5 Most all fax machines have a paper-load switch, loaded somewhere in the receiving paper path. If this switch is not activated, the machine assumes that no paper is installed—even if some is. Inspect your machine and find the switch. If the switch can't be found, refer to the service manual. When the paper is inserted and properly threaded through the mechanism, is the switch activated? Use your meter to check for continuity of the switch.

Step 2-6 The paper might be loaded and the paper switch operational, but the paper might still be jammed, refusing to advance through the mechanism. Unload the paper, tear or cut off a clean edge, and reinsert it.

Step 2-7 Many fax machines must be set up prior to use or they will refuse to function. Your setup information is stored in a "parameter list" and is maintained in the fax's memory by a small battery. Check that the parameter information has not been lost, or otherwise erased. Print out the parameter list, if possible, and carefully review it for errors or omissions. A weak parameter list backup battery will cause your fax machine to lose its setup memory. Replace the battery as needed.

Recording paper misfeeds

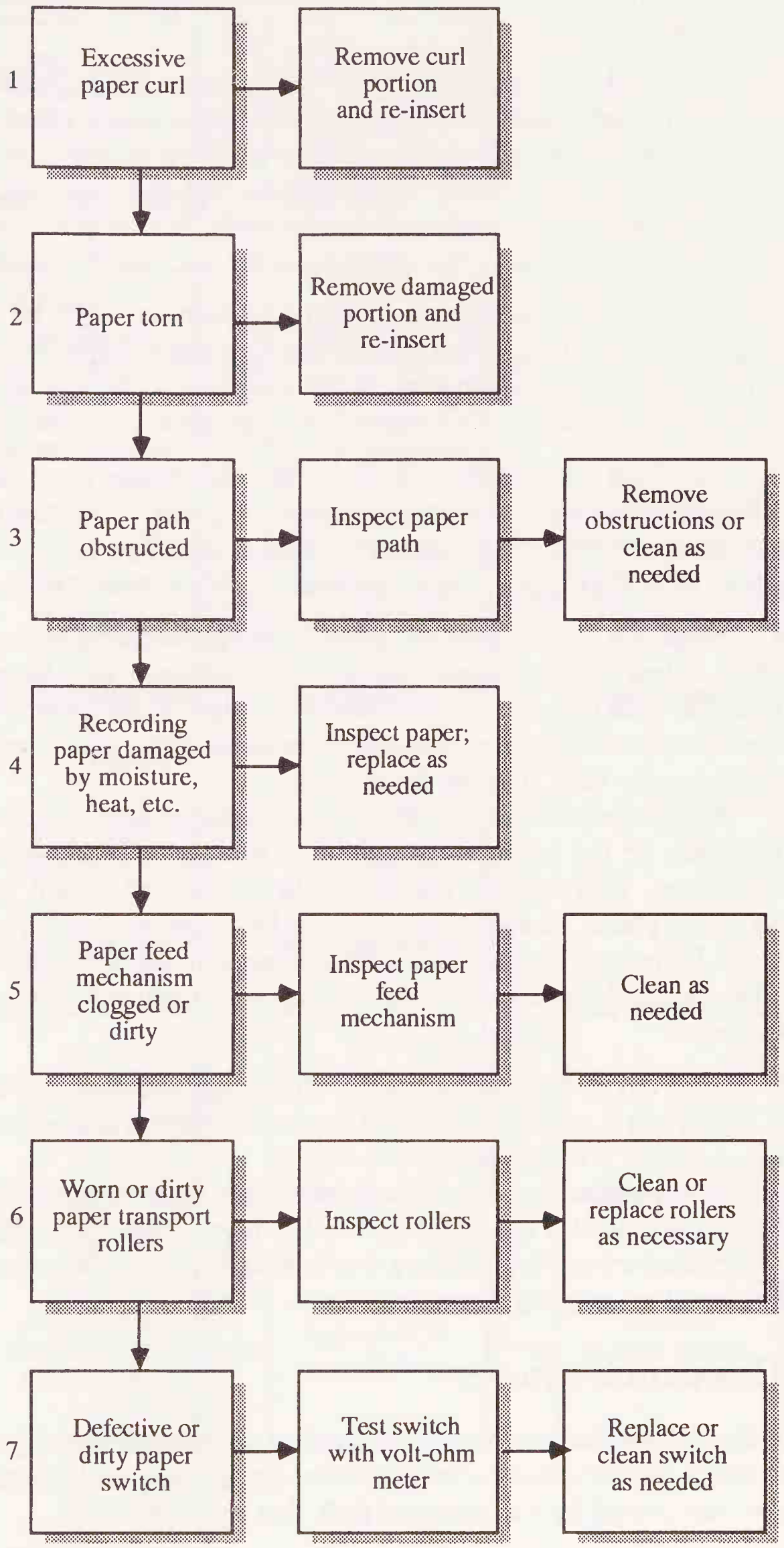
Documents you receive on your fax machine are printed on the recording paper. On thermal fax models, which are by far the most common, this recording paper is available in continuous rolls. The paper is cut into sheets by a paper cutter, if the fax is so equipped. Although recording paper is fairly hearty, it can become jammed. Check this section if you are experiencing annoying paper misfeeds.

Step 3-1 Recording paper has a tendency to curl—especially if it sits in the fax machine for any length of time. That curl can cause the paper to jam in the mechanism. If the paper is curled, remove the bad portion and cut it off. Reinsert the paper into the fax machine and try again.

If you use your fax machine only occasionally, you might need to cut off the curl before every document you receive. It might be a good idea to roll the excess paper back onto the roll after each use. This procedure will prevent paper curl that can jam the machine.

Step 3-2 A paper tear will cause it to misfeed through the mechanism. Cut out the bad portion and rethread. If the paper consistently tears as it is fed through the

3. Recording paper misfeeds



mechanism, it could be obstructed by a foreign object lodged in the paper path. See the following step.

Step 3-3 The path for the recording paper can be readily obstructed by bits of paper, tape, and other foreign matter. If the paper doesn't feed through smoothly without binding, check to see if something is blocking its way. Use a small flashlight if you can't see into the mechanism. Sometimes, you can clear the blockage by slipping a piece of heavy bond paper into the paper path. Be sure to remove all of the obstruction. Don't let it fall into the inner recesses of the fax, where it might cause more damage.

Step 3-4 Recording paper that has been damaged by heat, light, or moisture might misfeed through the fax machine. The paper might be more brittle and prone to breaking and chipping, or it could curl excessively. You can often spot damaged paper just by its appearance: if it looks yellow or gray, the paper should probably be replaced.

Step 3-5 Sometimes the paper-feed mechanism itself can become clogged with adhesive that is used to wrap the ends of the paper. Use a cloth dampened with isopropyl alcohol to remove the adhesive. Wait at least five minutes before rethreading the paper, or it might stick to the mechanism, and cause further problems.

Step 3-6 After time, the rollers in the paper transport can become dirty or worn. Dirty rollers can be cleaned with a cloth dampened with isopropyl alcohol. Carefully feed the cloth through the mechanism or wipe off the rollers if they are exposed. Be absolutely sure that the rollers and other components are completely dry before threading the paper back through the machine.

Worn rollers should be replaced. If replacements are not easily found, you can *sometimes* fix the problem by applying a small amount of rubber platen rejuvenator to the rollers. This solution will revive the rubber and help it to better grip the paper. Most any platen cleaner that is suitable for typewriters and computer printers will not work. Do not use a sticky tape rubber treatment, such as that for audio turntable belts. This chemical leaves a tacky residue that will gum up the fax mechanism, and rub onto the paper.

Step 3-7 A defective paper switch might not sense when paper is loaded or not. If the switch is jammed, it might assume the paper is properly loaded when it in fact is not. Look for the obstruction and clear it.

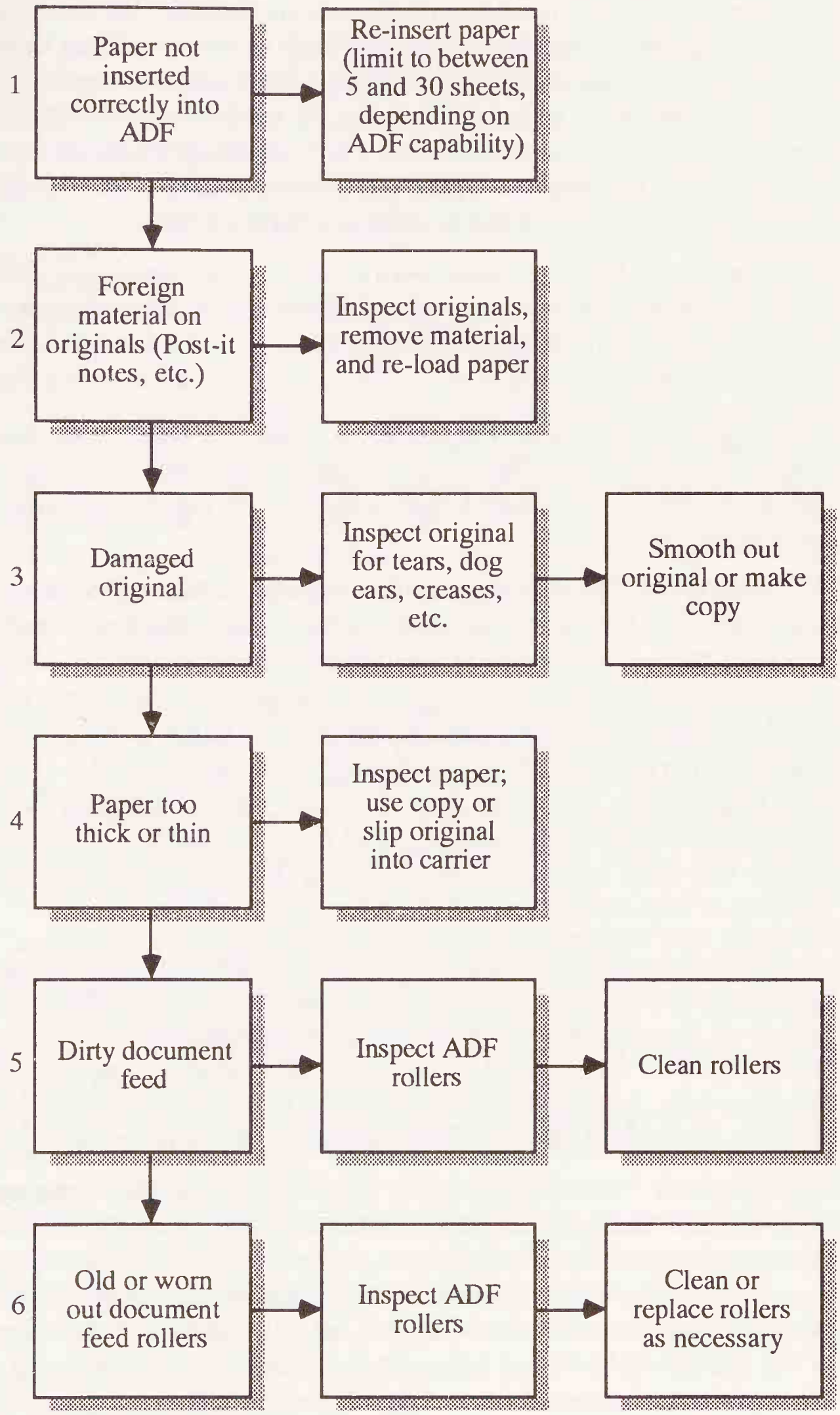
Most fax machines use a small leaf switch for the paper sensor. Because the switch must protrude into the paper path a bit, it can cause the jamming on its own. If the switch uses a metal leaf, be sure that it is not bent or broken. Inspect it with a flashlight and small magnifying glass.

Document jams

Whether your fax machine is designed to accept just one original at a time or a stack, troubles with original document feeder are actually quite common. Only occasionally are they caused by a mechanical fault that requires repair.

Step 4-1 On fax machines with a multiple-page document feeder, the paper often jams because it was inserted incorrectly. Most machines require that you carefully fan

4. Document jams



the original and position it in the document feeder so that the rollers will grab just one sheet at a time. Many machines require you to "feather" the paper by spreading out the leading edge of the sheets with about a 1/32th or 1/16th inch gap between each one.

Stuffing a stack of paper into the feeder at once, will almost always cause a paper jam. Load only a few pages at a time. Many machines are designed to accept less than ten 20-pound bond sheets in the automatic document feeder at once. If you have more pages to send, break up the transmission into smaller packets, or stand by the machine and manually feed the extras in while the fax is on-line.

Step 4-2 Be sure to remove all staples, notes, paper clips, and other foreign matter from your documents before you send them. Not only will these jam the paper-feed mechanisms, but they could do damage to the optical mechanism (for example, a staple can scratch the reader bar and cause a thick black line on every document you send).

Step 4-3 Creased, dog-eared, or crumpled paper does not feed through the mechanism well. It will likely cause a jam, particularly if you have loaded more than one sheet into the document feeder. Carefully smooth out the paper, or copy the original and fax the copy.

Step 4-4 The document-feed mechanism in the typical fax machine is designed to accept paper in a narrow range of thickness and finish. Best results are obtained with standard 20-pound bond paper, like ordinary copy or laser-printer paper. Paper that is thinner or thicker might jam in the feeder because the rollers can't adequately grasp it.

Jamming and misfeeds can also occur if the paper is overly slick (such as a magazine page or a glossy photograph). As long as the paper is not too thick, you can enclose slick originals in a fax carrier sheet. The clear sheet is designed like an envelope so that you can stuff an original inside it. Most fax machines have carrier sheets, but you can always buy them separate. If the sheet won't fit into the carrier, for whatever reason, it's best to first make a copy of the original and fax the copy.

Step 4-5 After time, grime, and dirty buildup from documents can cause jamming on a heavily used machine. You should periodically check the document feeder and clean it—especially if you send lots of documents that were produced on a plain-paper copier or were drawn by hand with lead pencil or marker. The toner from the copier and the graphite from the pencil can shed inside the fax machine. Mixed with a little bit of moisture, the caked-on sludge can hinder proper document feeding.

Step 4-6 The rollers used in the document-feeder mechanism can dry up and wear out over time, causing paper misfeeds. Inspect the rollers and look for cracks and other signs of age. You can attempt to rejuvenate the rubber in the rollers with an application of platen cleaner (the cleaner is available at most any typewriter repair shop). If possible, remove the rollers so that you can adequately coat the rollers with the cleaner. If the rollers will not come out easily, be careful to avoid dripping the cleaner on any other parts. Do not use alcohol to clean any rubber parts because the alcohol will dry up rubber.

Document-feed rollers that are severely cracked or misshapen as a result of prolonged pressure, as when the fax machine is not used for a long period of time) must be replaced.

Machine won't send/receive

Quite often, failure to send or receive a document is not the fault of the fax machine, but of the phone line. Because the machine depends on a proper telephone connection (including the connection on the other end, which you cannot easily monitor), these kinds of faults can be difficult to correct.

For simplicity in the following steps and chart, only sending documents are covered. You can apply the same troubleshooting techniques if your fax machine is refusing to receive a document.

Step 5-1 First check that the document you want to send is properly loaded into the document feeder. The machine won't send the document if it doesn't know that a piece of paper is ready to fax.

On machines with an automatic document feeder (and many that accept only one sheet at a time), a small leaf switch is used to detect when paper is loaded into the mechanism. Be sure that this switch is being triggered—you can often hear the switch snap on and off. If you know the switch is being activated, but the machine refuses to acknowledge that a document is waiting in the transmitting bin, use your meter to check the continuity of the switch. With the fax off, connect the leads of the meter to either side of the switch. Press the switch or insert a piece of paper into the mechanism. The reading on the meter should go between 0 and infinite ohms.

Step 5-2 Check the phone connection between the machine and the wall outlet. If your fax is equipped with a telephone handset, lift it and listen for a dial tone. If you can't hear a tone, the line is probably broken. You'll have to trace the wiring back to find the fault. Those fax machines not equipped with a telephone handset often include a "telephone" jack for connecting a separate phone instrument. Plug a spare phone into the jack and use it to listen for a dial tone.

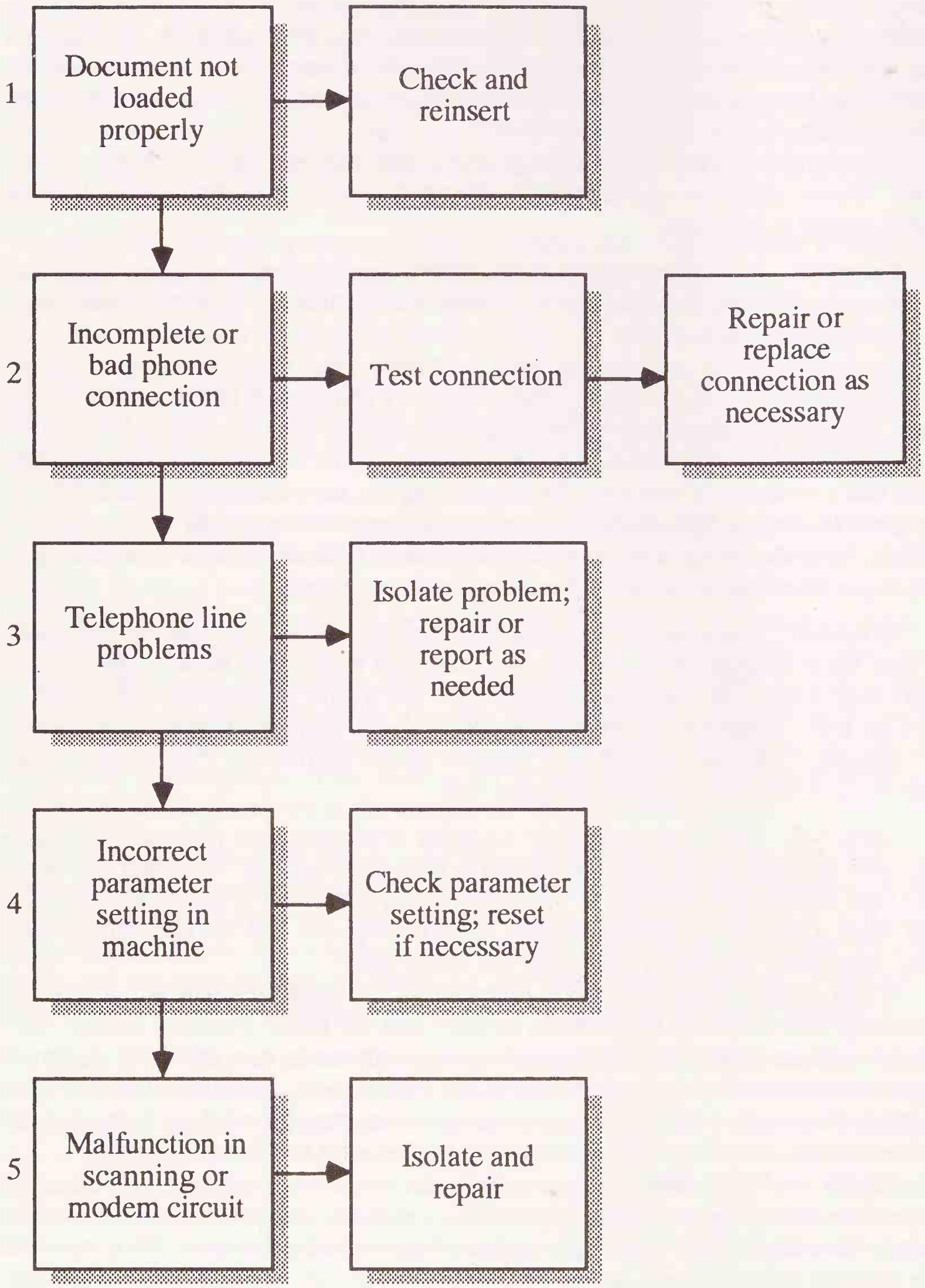
Step 5-3 You can do little about a number of telephone line problems. For example, your fax might be properly connected to the phone line, but you might not hear a dial tone unless the equipment at the telephone service center is ready to accept your call. Also, a dial tone doesn't necessarily mean that you can dial. Occasionally, you will hear a dial tone, but dialing the phone will have effect.

If you suspect a problem with the phone line, try testing the line with a standard telephone instrument. If the problem persists, call the phone company. Expect more phone problems during the winter months, when high winds, rain, and snow can wreak havoc on telephone wires. A connection might still be made, but the quality of the line might be extremely poor. This connection could cause your fax machine to hang up the phone because it can't establish a stable connection with the distant machine.

Should you have trouble connecting to the fax on the other end, the problem might be in their phone line, not yours. If possible, send a test document to another fax (or skip to the next job if you have many separate faxes to send). You can be fairly sure that the problem does not reside in your fax machine or in your wiring if you can successfully connect and communicate with other machines.

Step 5-4 OK, you've ruled out a line-related problem and your fax still refuses to send documents. Check the parameter settings on your machine (always a good idea

5. Machine won't send/receive document



whenever you have *any* problems with your fax). Look for other nonobvious control-setting errors. For example, are you accidentally sending the documents in "poll" mode? Doublecheck carefully and don't assume anything.

Step 5-5 On a mechanical and electronic level, a fax machine that won't send a document could have a malfunction in the scanning or modem circuits. You can test the scanning circuits by making a local copy of your document. Load one sheet of the document into the feeder and press the *copy* button. If it copies acceptably, you know that the scanner is working correctly. If your fax machine won't receive, the *copy* check will still be valid; if the copy does not appear, suspect a problem in the printing mechanism.

Although the modem circuit in your fax will seldom malfunction, it can happen—especially if the circuits were subjected to an electrical spike sent through the phone lines. A faulty modem circuit requires professional service.

You might consider adding a surge protector to the telephone line on your fax machine. The surge protector helps prevent large voltage spikes from reaching the sensitive circuitry in your fax machine. Although it won't guarantee total protection, it can be helpful—especially if you live in an area that is prone to electrical storms (lightning is a prime cause for voltage surges through telephone lines).

Document is scanned incorrectly

You've just finished sending a 100-page document when you receive an urgent phone call: each page of the document was smeared and illegible. The folks on the other end have tested their fax machine, and it's in perfect working order. They point the finger at you and your fax machine. It must not be scanning properly. Here's what to do.

Step 6-1 If the scanned page consists of smears, blotches, and vertical scratches, the culprit is most likely a dirty or damaged reader bar (horizontal scratches are usually caused by a transmission error, as detailed in the next step).

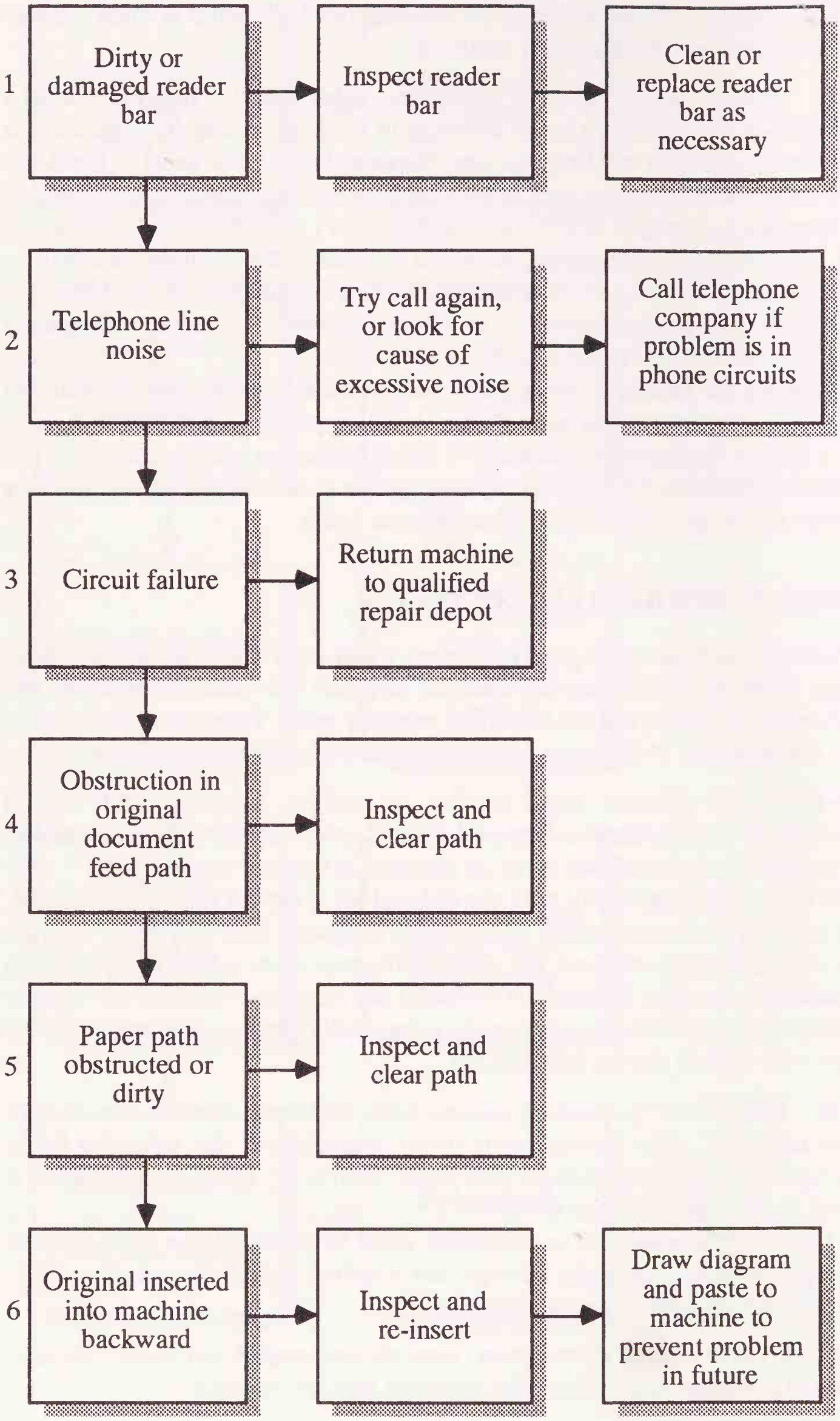
Clean the reader bar thoroughly with alcohol and let it dry (at least five minutes). Make a local copy by inserting a clean original into the paper feed and press the *copy* button. If the copy still looks smeared, try cleaning the reader bar again. If the problem persists, it could be caused by damage to the reader bar, in which case you will need to have the machine serviced (you can often replace the reader bar yourself, but you must be sure to carefully align it during installation).

Step 6-2 Transmitted documents spoiled with horizontal streaks are usually caused by line noise and other transmission errors—especially if the streaking looks random. Attempt to resend the document (you might want to try just a page or two as a test if you need to retransmit a large document).

You can rule out line noise and transmission error by performing a local copy, as detailed in the previous step. Because the *copy* function does not use the telephone line, the streaking should not appear on the printed sheet.

Step 6-3 If the streaking does persist, even on your copied test sheets, an electronic problem is probably in your fax. The machine requires service.

6. Document is scanned incorrectly



Step 6-4 If the received page contains blank areas, the probable culprit is something innocuous, such as a note stuck to the page. The cause is not likely to be a momentary data loss because if this problem occurs, most fax machines will either disconnect from the line or signal an error. Try resending the document.

Step 6-5 If the blank area appears vertically down the page, inspect the reader bar and look for obstructions, such as a note or a shred of paper. These can block the reader bar and prevent your document from being properly scanned.

Step 6-6 This cause is obvious, but it needs to be stated anyway: If the received pages are completely blank, consider the possibility that the sheets were inserted into the machine backwards. This problem happens more often than you think. Some fax machines are loaded so that the writing on the paper faces up. With others, the writing faces down. If you're not sure how to load the paper, check the manual or perform a quick test with the *copy* button.

Document is printed incorrectly

This problem is the reverse of the previous one: Your documents print with smears, blotches, voids, and other problems.

Step 7-1 First, rule out that the error is on your side of the fax link. This step is most conveniently done by producing a local copy. Place a test sheet in the document feeder and press the *copy* button. If the test print is smudged just like the document you received, you know the problem lies within your machine. Conversely, if the test print seems okay, consider the possibility that the error is in the sending fax, not yours.

Step 7-2 The printing mechanism of your fax is not as likely to become contaminated with the dirt and grime from original documents, but it does require periodic cleaning.

Wait at least ten minutes before cleaning the printhead (it can be hot). Open the fax, remove the paper, and clean the printer with alcohol. Allow the cleaner time to evaporate (about five minutes should do) and reload the paper. Try the local-copy test again.

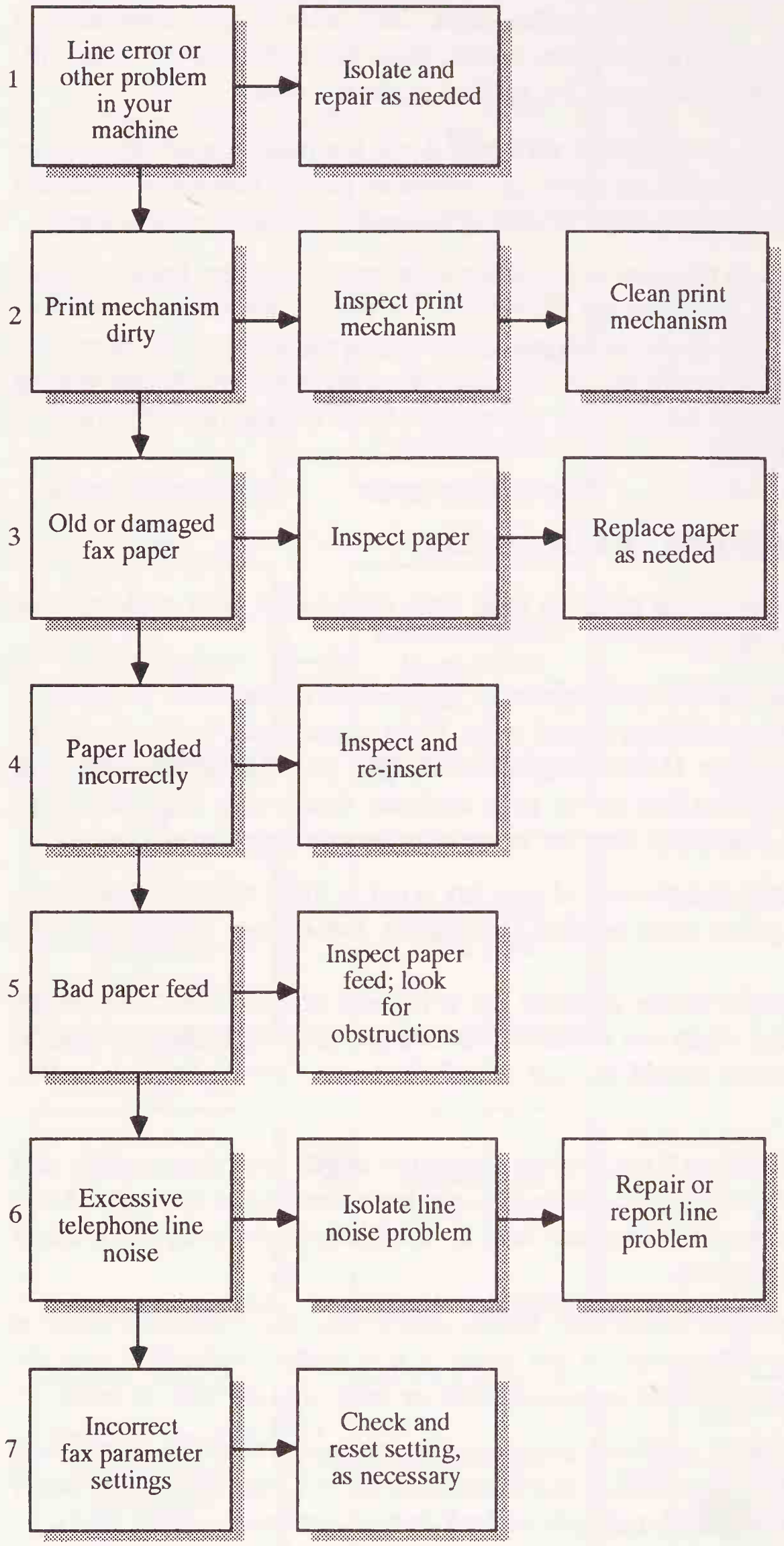
Step 7-3 Fax paper doesn't last forever. Old paper might not print properly and should be discarded. Also, discard the paper if it has been exposed to excessive heat, moisture, or sunlight. Inspect the paper and look for visual signs of damage. Try a new roll to see if the problem persists.

Step 7-4 If the print is completely blank, check that the recording paper is loaded properly. Nothing will appear on the paper if it is loaded backwards into the machine (or else the printing will be extremely light or fuzzy and difficult to read).

Step 7-5 Some printing problems are caused by improper recording paper feed. Watch the paper as it travels through the machine. It should not snag or jam (the paper should travel in short, well-spaced intervals, so look instead for erratic paper feed).

Step 7-6 Telephone line noise and other transmission errors can cause splotches and horizontal lines in the received documents. Your best bet is to try again. Hopefully,

7. Document is printed incorrectly



you will get a better phone line this time. If either the sender or you are experiencing bad weather, postpone the fax transmission, if possible. Otherwise, you might have to live with the poor document quality.

Step 7-7 Check to make sure that all the settings on your fax machine is correct. These settings include half-tone/gray-scale and print density. If your fax machine is the plain-paper thermal type, inspect the ribbon and replace it, if needed. If your machine is the plain-paper xerographic type, check the toner cartridge and replace it, if needed.

Fax does not respond to some or all front-panel controls

Failure to respond to some or all of the front-panel controls is often a mechanical fault, but it can also be caused by the electronics on the main PCB. If not all of the switches are affected, the problem might lie in the switches themselves.

Step 8-1 If the paper (recording or original) is not properly loaded, the front-panel controls might not appear to work properly. Remove the paper and reinsert it. Damaged or jammed paper can also cause the controls to behave erratically. Be sure to check the paper-sensing switches in the recording and original paper-feed paths. The switch could be dirty or broken.

Step 8-2 In many fax machines, you must already set all parameter options before you can send or receive documents. Doublecheck that the fax has all the information it needs to operate (print the parameter list if your fax has this option).

Step 8-3 Check for overriding operating, such as delayed broadcast or polling. If the fax machine is set on *timer* for delayed transmission later in the day, it might not allow you to send or receive documents in the interim.

Step 8-4 Given the right set of circumstances, switches can get broken, dirty, and corroded. Test each switch on the front panel to make sure that all work properly. Connect the test leads of ohmmeter to either side of the switch terminals. As you depress the switch, the meter should alternately read 0 ohms and infinite ohms. If not, the switch is faulty.

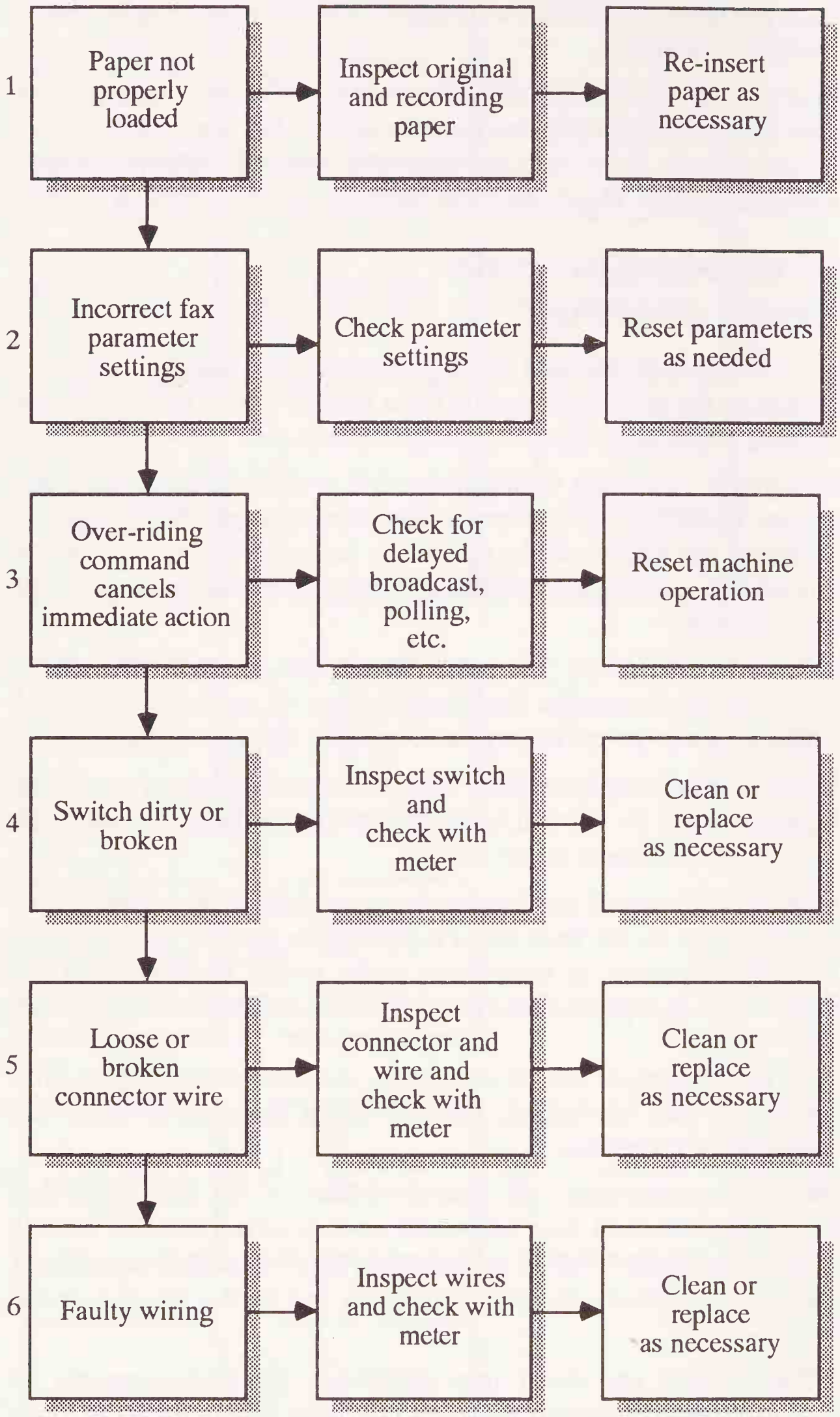
Unsealed switches can be cleaned with a nonresidue electrical contact spray. With the fax machine turned off and unplugged, liberally squirt the cleaner inside the switch. Broken switches must be replaced.

Step 8-5 Fax machines typically use separate PCBs for the front-panel and main (logic) circuits. A connector and wire harness is used to attach the two circuits together. Visually inspect the connectors to be sure that they are seated properly. A connector that is even loose can break the electrical circuit and render the front-panel controls inoperative.

Step 8-6 If the switches and connectors check out, the problem might be caused by faulty wiring. Carefully inspect the wiring that leads to and from the front-panel control switches. Look for obvious breaks, kinks, and cold solder joints. Use a meter to test the continuity of all affected switches.

The wiring harness that connects the front-panel PCB and the main PCB might be the flexible-membrane type. The connecting wires are copper bands that are glued to a

8. Fax does not respond to some or all front panel controls



flexible mylar base. These flexible ribbon connectors can be easily damaged if abused and are extremely difficult to repair. If you suspect a broken trace on the ribbon, double check the continuity with a volt-ohmmeter. A faulty ribbon must be replaced.

Front-panel indicators not functioning

You put in paper, press a speed-dial button, and everything works—the document is sent and properly received at the other end. However, the front-panel indicators in your machine are out of order, so you don't know exactly what it's doing. Check the following points if the indicators in your fax machine don't light.

Step 9-1 The indicators used in most fax machines come in two flavors: LED and LCD. These have exceptionally long life spans, so it is unlikely that they have simply "burned out" like light bulbs do. The probable cause is a bad wire or connector leading to the front panel or indicator.

Visually inspect all the wires that lead to the front-panel PCB and the indicator modules themselves. Use a volt-ohm meter to test for continuity. With the test leads connected at the ends of each wire, the reading should be 0 ohms. A reading of infinite ohms indicates that a wire is broken or that one of the solder joints is bad. Replace the wire or resolder as necessary.

Step 9-2 The wiring harness that connects the indicators and front-panel or main PCB might be the flexible-membrane type. The connecting wires are copper bands glued into a flexible base. These ribbon connects can be easily damaged and are nearly impossible to repair. If you suspect a broken trace on a ribbon, check the continuity with a volt-ohmmeter. Replace if it is bad.

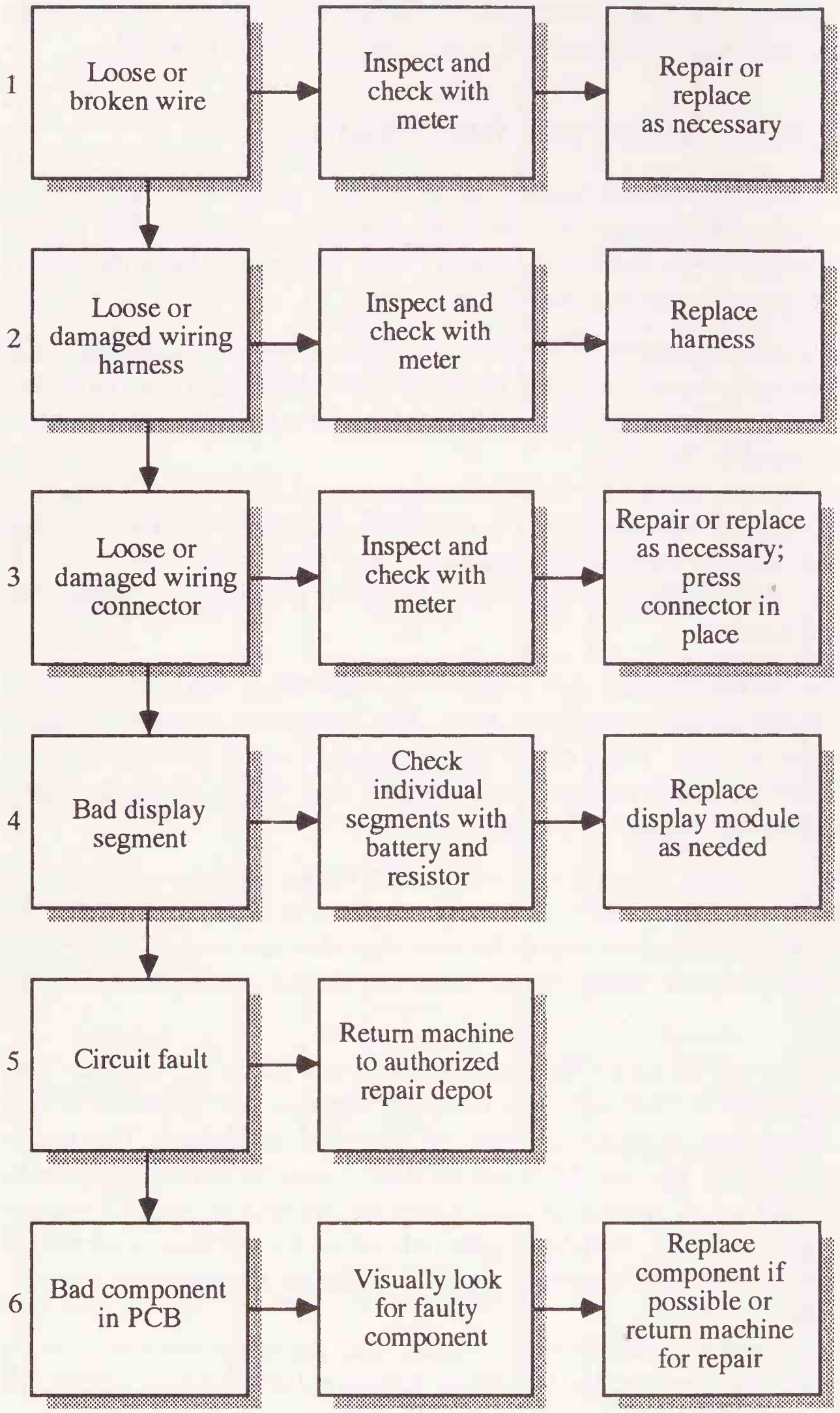
Step 9-3 Fax machines typically use separate PCBs for the front-panel indicators and main circuits. A connector and wire harness is used to attach the two circuits together. Visually inspect the connectors to be sure that they are seated properly. A connector that is even loose can break the electrical circuit and render the indicators inoperative.

Step 9-4 Rarely will all LEDs and number segments black out at once. The more common occurrence is that only one indicator lamp or one segment in one numeral will fail. Check first to make sure that the wiring is not at fault. Use a volt-ohmmeter as before. You can also test LED and LCD indicators by connecting them to a 9-volt battery through a 1 K resistor (do not forget the resistor or you will permanently damage the LED or LCD). Test the display only when the machine is turned off and unplugged. The polarity of the battery is important. Reverse the polarity if the indicator doesn't activate.

If one or more indicators or segments are indeed bad, the entire module must be replaced. You cannot repair or replace individual indicators or segments within the module.

Step 9-5 A blank indicator panel might also be caused by a fault in the fax machine. Be sure that the machine responds to all front-panel controls. If it does not, refer to Flowchart 8 for more information.

9. Front panel indicators not functioning



Step 9-6 If all checks out so far, the fault might be a bad component on the front-panel or main PCB. If the fax machine works fine in every other regard, but the indicator panel is blank or scrambled, the problem might be a faulty driver IC or other component on the front-panel or main PCB. Should this be the case, the components or PCB must be replaced.

You receive an electric shock when you touch the machine

You should never receive an electric shock when you touch a fax machine (a static shock, such as walking across the carpet on a dry day, doesn't count). An electrical shock, even a mild one, is a good indication that the fax is malfunctioning, and poses a potential health threat.

Receiving a shock could show a faulty component in the fax and that some of the ac current is leaking to the chassis or the machine. You can test for leakage current with a volt-ohmmeter. Refer to chapter 6 on how to perform this test.

Step 10-1 Water is a poor conductor of electricity, but it's good enough to short the ac power cord or the power supply terminals in your fax machine. Condensation can also form a light film of moisture that can conduct some current. Although the shock might be slight to the human body, it could damage the fax components.

Inspect for moisture; if found, let the machine dry for at least 30 to 60 minutes with the power off. You can hurry along the process by using a common hair dryer. Place the dryer in *low* or *no heat* only setting. If a lot of water is inside, blot up the excess and spray the interior of the machine with a nonwater-based cleaner (refer to chapters 4, 5, and 6 for suggestions). Never use WD-40 because it has a tendency to displace the water and remove it from hard-to-reach places.

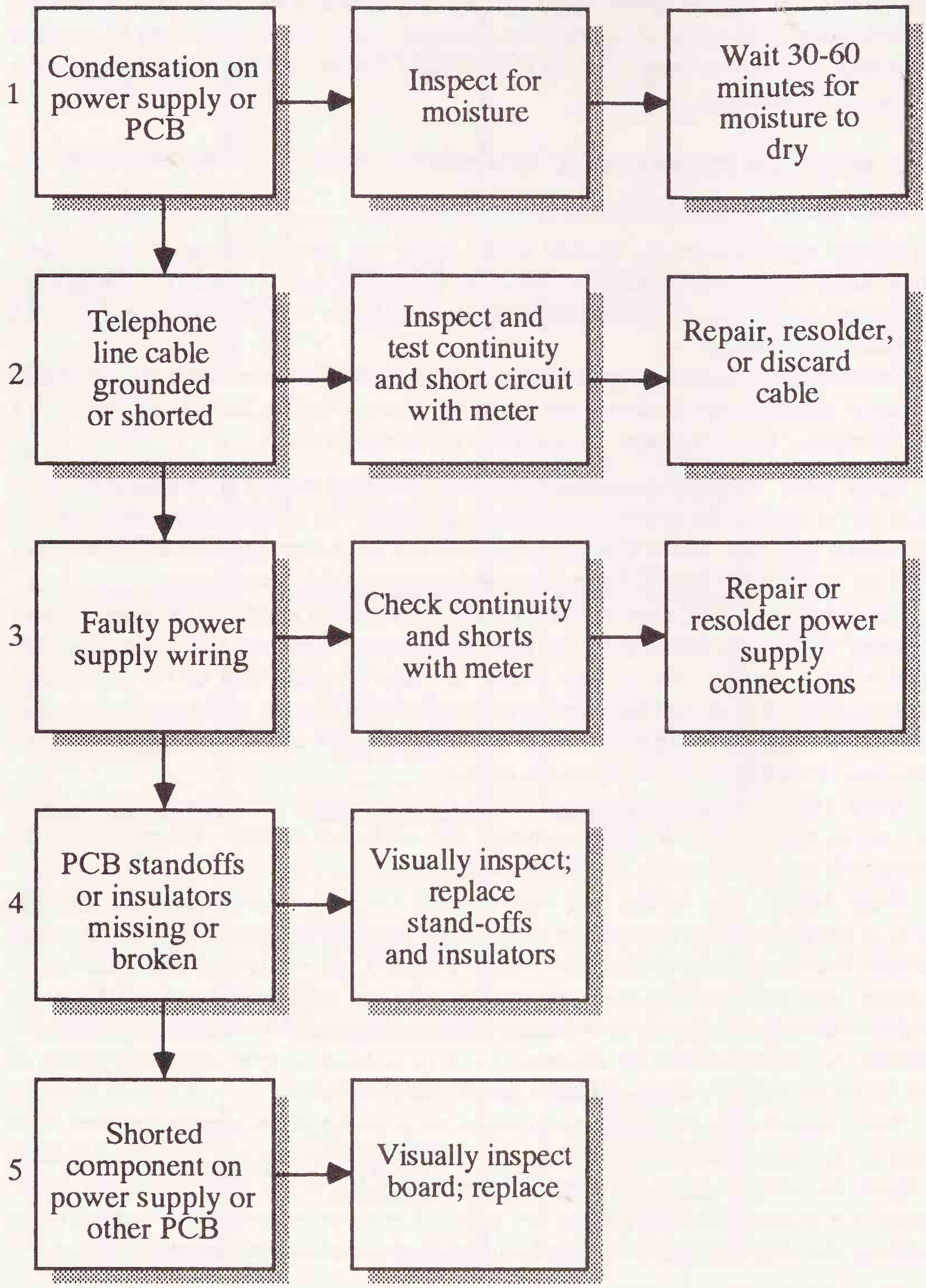
Step 10-2 Look for shorts or frays in the telephone wiring. The phone connection carries about a 50-volt charge—enough for you to feel a shock. You can check the wiring with a volt-ohmmeter and by visual inspection.

Step 10-3 The wiring that leads to and from the power supply in the fax machine could be faulty. Inspect the ac cord that leads to the power switch and power transfer. Use your meter to check for short circuits (a low reading of a few kilohms is probably okay, but a reading at or near 0 ohms is a good indication of a short). Examine the power transformer for obvious damage. Check the solder terminals so that none are touching the cabinet of the fax machine. Look close because even one small strand of wire in the ac cord can cause at least a partial short circuit.

Next, examine the wiring from the transformer to the power-supply circuitry. This is sometimes located at its own PCB, and other times on the main PCB. Use your meter to check for obvious short circuits. At least one of the wires from the power transformer will act as the chassis ground for the fax. You should receive a low reading when checking this wire. The other wires should yield reasonably high resistances.

Step 10-4 The power supply and main PCBs are generally insulated from the cabinet and base with plastic standoffs. If secured with metal hardware, the boards are electrically isolated from the cabinet with plastic or rubber insulators. Inspect the

10. You receive an electric shock when you touch the machine



mounting hardware to see if any parts of the boards are touching the base or cabinet. Inspect the insulators and look for breaks and cracks. Replace any broken standoffs or insulators.

Step 10-5 Finally, a faulty component on any of the printed circuit boards in the machine might cause some current leakage. Not all components are crucial to the operation of the fax, so if a part shorts out (like a filtering capacitor), the unit might still operate—at least on a marginal level. Visually inspect the components on the boards for obvious damage, and either replace the parts (if possible) or replace the PCB.

Fax overheats

A fax machine that becomes abnormally hot is not only a potential fire hazard, but it will exhibit erratic behavior. You can easily tell if the deck is becoming warmer than normal by touching its cabinet. It should not be noticeably hot to the touch. If it is, you should investigate the problem before using the machine. Continued use of the fax could damage it beyond repair.

Step 11-1 Fax machines consume little power, so cooling is not as critical as with a 100-watt audio amplifier, for example. Still, most machines rely on ventilation slots for proper operation (a few heavy-duty ones use a blower fan). It is important that these slots are not blocked, either by some outside object or by dust and dirt. If the slots become blocked with dirt, use a brush or vacuum to clean them.

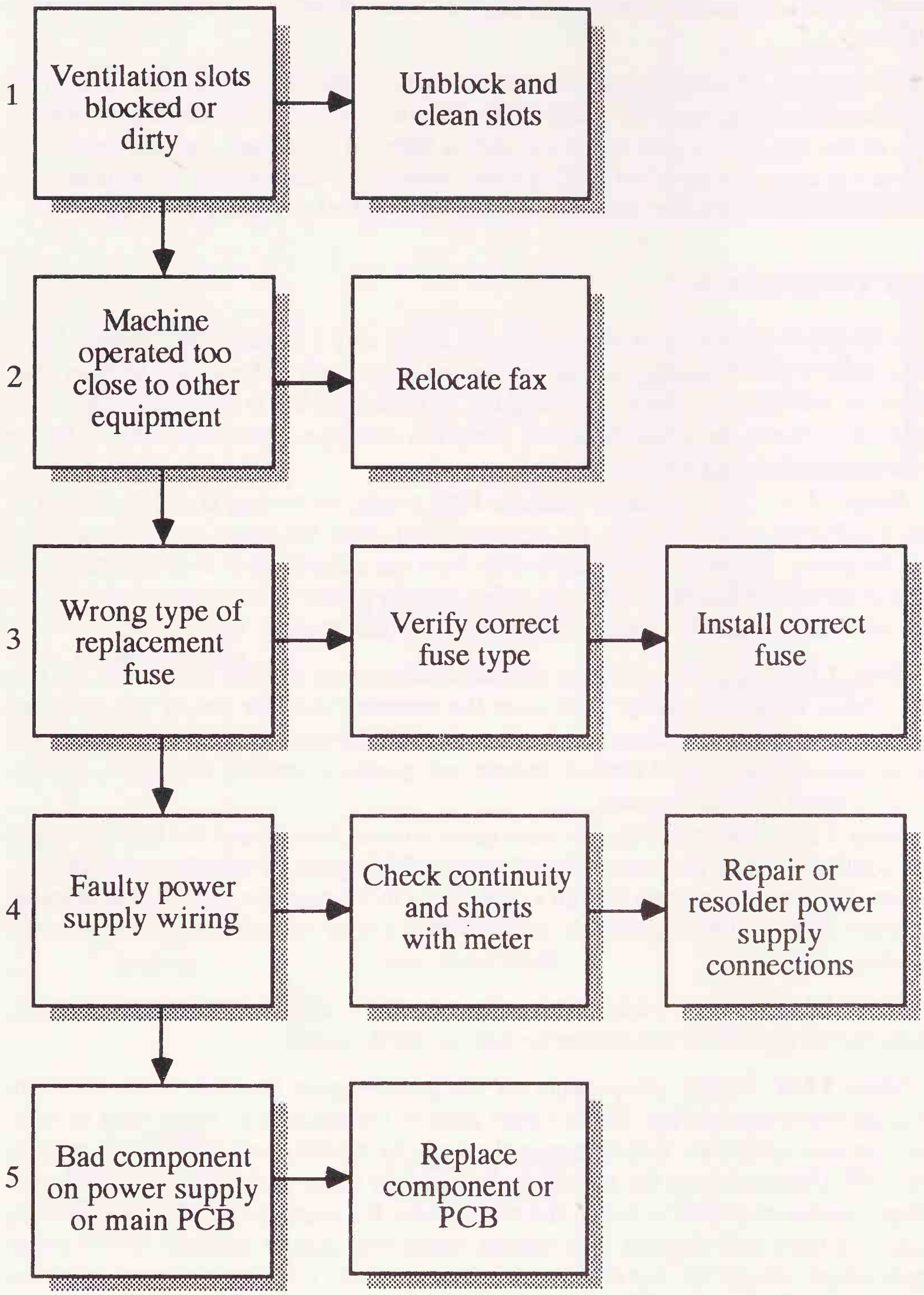
Step 11-2 A fax operated too close to another piece of office equipment, such as a big copier, might get overly warm from the external heat. For proper fax operation (and for longer paper life), keep the machine physically separated from any other device that generates heat. These devices include refrigerators, vending machines, copiers, and (of course) heating registers.

Step 11-3 Fax machines use external or internal fuses (many use both). If a fuse blows, replace it with the same value of fuse as the original. If a higher value is used, the fuse might not blow, even though a component in the machine is shorted or drawing excessive current. These problems could cause a fire or considerable damage to the machine.

Step 11-4 Faulty wiring in the power supply can likely cause overheating. Check the wiring with a volt-ohmmeter against short circuits.

Step 11-5 Faulty components on the power-supply board or main PCB can cause excessive overheating. You can often identify the responsible component by carefully touching each one. To test, power the deck for a while until the heat rises, then turn it off. Unplug it from the ac wall socket. Lightly touch each component. Only the voltage regulators should be hot to the touch (some ICs might be quite warm, but they should not burn your fingers). The voltage regulators, usually mounted on the power supply board, can get hot, but they are usually kept within a safe operating temperature by the use of aluminum heatsinks.

11. Fax overheats



Appendix E

List of EIA recommended test equipment

The Electronics Industry Association (EIA) is a nonprofit national trade association set up by a number of electronics manufacturers, many of whom make facsimile machines. One of the charters of the EIA is to establish maintenance standards and recommend test equipment for various types of consumer electronic equipment.

Among their recommended lists are test equipment for servicing fax machines on a board-level basis. You probably won't do this procedure as a consumer, but it might be helpful for you to know the type of standard test equipment that is required to do the job properly.

The following is a list of recommended test equipment, as drawn from *EIA Recommended Test Equipment for the Consumer Electronics Industry*, Revision 3, 1990. This publication, which is available from the EIA, lists a number of consumer electronics products; this coverage is limited to just facsimile machines.

Test Equipment	**Specifications**
Ac leakage tester	500 μA capacity
Digital voltmeter	0.1 to 100 Vdc Sensitivity: 1 mV Accuracy: 0.5%
Dual trace oscilloscope	Triggered input; time delay Bandwidth: dc-100 MHz Sensitivity: 2 mV
Frequency counter	250 MHz
Isolation transformer surge protector	Model equiv: Panamax, IEFI

Test Equipment	Specifications
Telephone analyzer	Model equiv: B&K model #1050, Protel TEE-10, Proctor 49200, or Micro Seven, Inc. LS100 and LS200
Test chart	DQ Test Target Dataquest or Slerexe Letter CCITT Test Chart #1

Glossary

activity report A printed report, generated either automatically or upon request, that provides details concerning documents sent to and received from a fax machine. Activity reports are often used for billing and accounting purposes.

analog Data transmission in which information is sent in a continuously varying signal, as opposed to digital, where the information is either on or off.

autodial A feature whereby commonly used telephone numbers are dialed from memory by the fax machine.

automatic document feeder (ADF) An attachment or feature of some facsimile machines where single sheets of an original document are sequentially fed into the scanner of the fax for transmission.

automatic paper cutter A device built into some fax machines that automatically cuts the paper to size after printing a single page.

automatic speed selection A feature that enables the fax to select the correct communication speed based on: **1.** The capabilities of the remote fax; **2.** The condition of the telephone line.

bandwidth The amount of information that can be carried at once through a communications channel. Bandwidth increases as the frequency range (expressed in Hertz or cycles per second) of the channel increases. The broader the frequency range, the higher the bandwidth.

baud A unit of transmission and reception speed; in many cases, equal to data bits per second.

bit A binary code, either 1 or 0 (for on and off states, respectively).

bits per second (bps) The number of data bits transmitted through the phone line in one second.

broadcast Sending a single document to more than one recipient, also called *sequential broadcast*. Fax machines that contain electronic memory are capable of broadcast.

buffer Memory storage for temporarily holding data so that it can be processed by the fax at a later time.

byte A collection of bits (usually eight) that are considered a discrete unit. In modem communications, bytes represent printable characters.

carrier A modulated electrical signal that carries information.

CCD (Charge-Coupled Device) A solid-state electronic component that is often used in the scanning system of fax machines. The CCD provides "eyes" for the fax.

CCITT Acronym for the *Consultative Commission on International Telephone and Telegraph*; a nonpartisan European commission that is charged with overseeing standards in telephone communications.

compression Packing data in a smaller format. The compressed data is in a "shorthand" form, which must be decompressed before it can be used by the computer.

data pump The component or subsystem of a fax or modem that converts the digital signals supplied by the computer into audible tones for transmission through the phone lines. The data pump in the receiving fax or modem converts the audible tones back into digital signals.

delayed broadcast (transmission) A feature for sending a document at some later time, typically after hours when phone rates are lower.

dial-up line A publicly shared telephone line that can be accessed by dialing the number of the remote modem. See also *leased line*.

digital Data transmission in which information is sent in two discrete states, on and off (signified by 1 and 0, respectively), as opposed to Analog, which is sent in a continuously varying signal.

error correction method (ECM) A recently adopted, optional error detection and correction scheme endorsed by the CCITT, and found on some Group 3 fax machines. Data that has been garbled by a poor phone line is automatically retransmitted.

error detection A hardware or software protocol to analyze incoming data and determine if the received data contains an error. If an error is detected, the most recently transmitted data bits are resent. See also *parity*.

facsimile (fax) An exact duplicate of an original. In common usage, facsimile means a device for sending and receiving documents through the telephone.

fallback To decrease the transmission to a slower speed automatically, as dictated by the maximum speed of the receiving machine or by poor quality telephone lines.

full duplex Simultaneous two-way communications; sending and receiving data at the same time.

gray scale See *halftone*.

Group 1, 2, 3, 4 Transmission standards, set either by manufacturers (in the earlier days of facsimile) or by the CCITT, which dictate parameters such as speed and sharpness of transmission. The current de facto standard is Group 3, though many Group 3 machines can also send and receive in Group 1 and Group 2 modes.

half duplex Two-way communications, but the data is sent or received in one direction at a time only.

halftone A setting found on some fax machines whereby a photograph or other graphic containing colors and shadings can be transmitted and received in distinct levels of gray, not just black and white. Without halftone transmission, photos come out blotchy and indistinct. Fax machines differ in the number of halftone steps (or gray scale) that they are capable of reproducing, typically between 8 and 64.

handset A telephone handpiece that is built into some facsimile machines.

handshake A process whereby two devices (including fax machines) can establish a communications link. Once handshaking has been established, indicating that the devices are able to trade information without data loss, the rest of the transmission can be sent.

Hertz (Hz) Cycles per second. For example, the bandwidth of the average telephone line is between 300 and 3,000 Hertz, or 300 to 3,000 cycles per second.

hub A facsimile used as a central communications device for a group of people, typically a number of departments in a big company. The hub fax is often directly connected to smaller, special-purpose fax machines within the same office.

impairment The generic term for a flaw in telephone line quality, which is usually caused by echo, noise, or a drop in signal strength.

LCD Acronym for *liquid crystal display*. A read-out panel that is used to provide status and messages to a fax operator.

leased line A special line leased from the telephone company for the express use by an individual or organization. Leased lines are generally conditioned so that impairments are kept at a minimum. See also *dial-up line*.

line monitor A speaker built into the fax-phone that lets the user listen to the line (dial tone, ringing, answer, etc.) without using the handset.

lines per inch Resolution of facsimile transmission or the number of lines that are used for printing text and graphic images in one inch. Sometimes lines per inch are stated as *dots per inch* or *pels*.

mail box transmission/reception As found in select models of fax, a portion of memory that is used to store a document for transmission or reception. The document is not left in the automatic document feeder or printed, which prevents others from seeing it. Only persons with the correct access code can view the document.

modulation Method of varying an electronic signal so that it can carry intelligent information. In the case of fax communications, that information is an electronic image of your document.

out-of-paper reception The ability of a fax machine to continue receiving a document even though it has run out of paper. The data for the document is retained in memory; the images will be printed out when you add more paper.

paper cutter See *automatic paper cutter*.

parity An extra bit tagged to the end of a data character that is used to check for errors in transmission. The value of the parity bit (either 0 or 1) is determined by adding the values of the bits in the transmitted character. If both modems in the link obtain the same value for the parity bit, the data is assumed to be correct. If the value of the parity bit does not agree, the data is assumed to be in error.

pels Picture elements. Equivalent to the dots that compose a fax image.

plain-paper printing Printing of received documents on plain bond paper, instead of on thermal paper. See *thermal printing*.

polling The ability to make on call and both send and receive a fax, or to call a remote fax location and request a fax transmission. The various types of polling are: *free* or *general* (the remote fax will send the document following any request), *turnaround* (the fax lets you send and receive documents in a single call), *secure* (the remote fax will only send the document following a coded request), and *delayed* (the

polling request is made automatically by the fax machine at a predetermined time).

printed call back A message printed at the end of a transmitted document that requests the receiving station to call the transmitting station.

protocol A transmission standard where communications between two facsimile machines are alike so that they can send and receive data between them.

recording paper The paper used to print a document received from another fax.

relay broadcast A feature found in some facsimile machines where a fax can receive, then resend a document to other remote fax locations. Relay broadcast requires the use of compatible units, usually similar models or makes.

resolution The ability to reproduce fine detail. In facsimile, three distinct resolutions are used: *standard/normal* (about 100 by 200 lines per inch), *detail/fine* (about 200 by 200 lines per inch), and *superfine* (about 200 by 400 lines per inch).

scan width The maximum width of paper that the scanning electronics in the fax can see. The scan width is typically less than the maximum width capacity of the original; if the fax accepts originals up to 8 1/2 inches wide, the scan width is generally an 1/8 to a 1/2 inch less.

sequential broadcast The ability to send the same document (typically from memory) to many remote fax locations. See *broadcast*.

speed dialing Autodial phone numbers that you can access by pressing just one or two buttons.

store-and-forward The use of memory in a fax machine for sequential broadcast.

thermal printing Printing on specially-coated, thermal-sensitive paper. Typically, thermal-sensitive paper is on a long roll that is cut to the desired page length—either by the fax machine or by the user. See *plain-paper printing*.

thermal-transfer printing A printing process whereby heat melts a waxy ink from a ribbon; the ink is then deposited onto the paper.

throughput The amount of data bits that are transmitted from one computer to another through a modem-to-modem phone link.

voice request An indicator found on some fax machines that shows when the operator at the remote fax location wants to talk with you. Both sending and receiving faxes must be capable of voice request.

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A time- and money-saving guide to trouble-free fax machine performance

Although a fax machine is a bundle of high-tech circuitry, keeping one in good operating condition doesn't necessarily require servicing by a high-priced electronics technician. Most of the problems that occur with fax machines are caused by faults you can fix yourself—dirty switch contacts, broken wires, dirty printing elements, aging rubber belts and rollers, and damaged paper.

Here, electronics expert Gordon McComb shows step-by-step how to maintain and repair all types of fax machines with just a few low-cost tools and supplies. ***Troubleshooting and Repairing Fax Machines*** provides you with simple, illustrated instructions that explain how to:

- Clean and lubricate the paper path, light-sensitive reader bar, thermal printing mechanism, paper cutter, fluorescent lamp, and front panel controls
- Diagnose and fix bad phone connections and printing and transmission errors
- Administer fax first aid in case of fire, water, and other damage

. . . and much more. You'll also find an entire chapter devoted to using troubleshooting flowcharts to locate and solve problems. With ***Troubleshooting and Repairing Fax Machines,*** you'll be amazed at how easy and inexpensive it can be to keep your fax machine online and working properly.

About the Author

Gordon McComb is a technical writer who has written for *Popular Science, Popular Electronics, Omni,* and *PC Magazine.* His books for TAB include *Troubleshooting and Repairing VCRs—2nd Edition* and *Gordon McComb's Tips and Techniques for the Electronics Hobbyist.*

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